2022 Air Quality Annual Status Report (ASR)

In fulfilment of Part IV of the Environment Act 1995

Local Air Quality Management

September 2022

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Executive Summary: Air Quality in Our Area

Air Quality in Carlisle City Council

Air pollution is associated with a number of adverse health impacts. It is recognised as a contributing factor in the onset of heart disease and cancer. Additionally, air pollution particularly affects the most vulnerable in society: children, the elderly, and those with existing heart and lung conditions. There is also often a strong correlation with equalities issues because areas with poor air quality are also often less affluent areas[1,2].

The mortality burden of air pollution within the UK is equivalent to 28,000 to 36,000 deaths at typical ages[3], with a total estimated healthcare cost to the NHS and social care of £157 million in 2017[4].

Air quality has been monitored in Carlisle and the surrounding district as part of the local authority review and assessment process since 1996. In addition to nitrogen dioxide, other pollutants measured include particulate matter (in two size ranges; $PM_{2.5}$ and PM_{10}) and benzene (measured as part of Defra's Non-Automatic Hydrocarbon Network). However, as local authorities are no longer required to report benzene concentrations we are not reporting these in this Annual Status Report.

Following the impact of Covid-19 in 2020, for which NO_2 concentrations measured by diffusion tube decreased on average by 20 % compared to the previous four years, the NO_2 concentrations increased on average by 3.5 µg m^{-3} in 2021 compared to 2020 and remain below the 40 µg m^{-3} annual mean AQO within our AQMAs and all locations across the Council Area.

Nitrogen dioxide concentrations measured by the automatic analyser also remained below the annual objective concentration in 2021. The annual mean NO_2 concentrations were

[1] Public Health England. Air Quality: A Briefing for Directors of Public Health, 2017

[2] Defra. Air quality and social deprivation in the UK: an environmental inequalities analysis, 2006

[3] Defra. Air quality appraisal: damage cost guidance, July 2021

[4] Public Health England. Estimation of costs to the NHS and social care due to the health impacts of air pollution: summary report, May 2018

22.5 µg m^{-3} at Paddy's Market. This represents an increase of 18.7 %, compared to previous years. There were also no exceedances of the hourly mean objective. The highest annual mean NO_2 concentration (36.3 µg m^{-3}) measured anywhere in the diffusion tube network was at site E8 within the Bridge Street AQMA.

The PM_{10} annual mean concentration monitored by automatic analyser at Paddy's Market was 17.2 µg m^{-3} in 2021 and hence significantly below the annual mean air quality objective of 40 µg m^{-3}. There were also no exceedances of the short-term air quality objective.

Before 2021, the air quality measures introduced by Carlisle City Council, had tended to decrease NO_2 concentrations at all locations throughout the local authority. However, NO_2 concentrations before the pandemic suggested that the following AQMAs should remain:

- AQMA 1 (A7):
- AQMA 2 (Currock Street);
- AQMA 4 (Bridge Street);
- AQMA 5 (Dalston Road).

AQMA 1[5] was significantly reduced in size; it no longer includes the area along the A7 from Hardwicke Circus to Junction 44 of the M6 instead it includes just an area extending for approximately 100 m from the Stanwix Bank junction (A7) along Brampton Road including properties 1 to 17 on Brampton Road. The order came into force on 25th July 2019.

The orders for revocation of AQMA 3[6] and AQMA 6[7] came into force on 3rd July 2019. Copies of the orders can be obtained from www.carlisle.gov.uk (see footnotes below).

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5 https://www.carlisle.gov.uk/Portals/0/Documents/Residents/Environment/Air%20Quality%20Management%20Order%20No%201%20.pdf

6 https://www.carlisle.gov.uk/Portals/0/Documents/Residents/Environment/AL517%20-%20Order%20Revoking%20Air%20Quality%20Management%20Order%20Area%20No%203.pdf

7 https://www.carlisle.gov.uk/Portals/0/Documents/Residents/Environment/AL517%20-%20Order%20Revoking%20Air%20Quality%20Management%20Order%20.pdf

They can be viewed on the Department for Environment, Food and Rural Affairs (Defra) website: https://uk-air.defra.gov.uk/aqma/local-authorities?la_id=48

Carlisle City Council work alongside partners in Cumbria County Council, Highways Department and their consultants. We are in early-stage discussions on the potential to introduce new smart traffic signals, within the city centre. This could potentially be combined with continuous air quality monitoring, to reduce traffic derived emissions, in line with our Action Plan measures. This future project may involve an application to secure some grant funding from Defra.

Actions to Improve Air Quality

Whilst air quality has improved significantly in recent decades and will continue to improve due to national policy decisions, there are some areas where local action is needed to improve air quality further.

The 2019 Clean Air Strategy[8] sets out the case for action, with goals to reduce exposure to harmful pollutants. The Road to Zero[9] sets out the approach to reduce exhaust emissions from road transport through a number of mechanisms; this is extremely important given that the majority of Air Quality Management Areas (AQMAs) are designated due to elevated concentrations heavily influenced by transport emissions.

Carlisle City Council has taken forward a number of measures during the current reporting year in pursuit of improving local air quality. Key local measures continue to support improvements in local air quality and the City Council continues to work on:

- Carlisle Southern Link Road: This will connect Junction 42 of the M6 with the A595 to the west. The route will include new junctions linking existing radial routes into Carlisle and the Garden Village. The 8km section of new road will complete a bypass route around the city centre. It will include bridges over two main railway lines and the Caldew and Petteril rivers and a network of footways and cycleways.

[8] Defra. Clean Air Strategy, 2019

[9] DfT. The Road to Zero: Next steps towards cleaner road transport and delivering our Industrial Strategy, July 2018

- Bus infrastructure improvements: Ongoing improvements to bus services continues. Several plans for large new housing developments will also include public transport provision.
- Plans are developing to introduce new, cloud based, smart traffic signals, within the city centre. This could be combined with a network of continuous air quality monitoring sensors, to reduce traffic derived emissions within two AQMA's. Subject to Defra grant funding application.
- Ongoing work to provide grant funding for home insulation and domestic renewable heating options.
- Ongoing schemes to introduce vehicle charging points on council owned land and as part of new private development, including charging provision in all new residential developments.

Conclusions and Priorities

Following the reductions in nitrogen dioxide concentrations due to Covid-19 in 2020, concentrations had increased through the Council Area in 2021. Although there were no exceedances of the annual objective concentration for NO_2 at locations relevant for human exposure anywhere in Carlisle City Council, concentrations within the Bridge Street AQMA (AQMA 4) are now within 10 % of the air quality objective which suggests there is a risk of exceedance.

Before 2020, monitoring of pollutants had shown a gradual but steady decline in nitrogen dioxide (NO_2) and particulate (PM_{10} and $PM_{2.5}$) concentrations. Particulate measurements are well below the air quality objectives. Some locations across the city are just below the air quality objectives for NO_2. It is expected that NO_2 will return to pre Covid-19 concentrations within 2022 or 2023. As a result, it is too early to consider changing the AQMAs within Carlisle City Council.

Monitoring should continue to ensure the ongoing measures in the AQAP are achieving success.

Carlisle City Council's priorities for the coming year are:

- Make progress on the measures identified in Action Plan 2021.

- Promote travel plans and introduction of green spaces for all new housing developments. Encourage zero and near zero emission vehicle uptake as part of new residential development.
- Continue to work with businesses to promote more widespread use of alternative transport and minimise emissions to air from industrial sources.

Local Engagement and How to get Involved

There are a number of ways in which the public can get involved with improving air quality:

- Taking part in Green Travel Plan arrangements with their employer.
- Joining local cycle groups and walk to school/work groups.
- The use of sustainable transport options including cycling, walking and the bus.
- Investigate how to improve the energy efficiency at home, including sustainable heating and improved home insulation. Contact Carlisle City Council to find out what grants are currently available.
- Become involved in community groups such as the Local Enterprise Partnership (LEP), which works to secure government grant funding for local projects.

The Carlisle City Council website can be used to view all previous air quality review and assessment reports as well as real time monitoring data and advice on how to reduce emissions to air.

Local Responsibilities and Commitment

This ASR was prepared by the Environmental Health Department of Carlisle City Council with the support of the following officers and departments:

- Carlisle City Council, Highways Manager.
- Cumbria County Council Highways and Transport Department.
- Ricardo Energy and Environment, Air Quality Consultants.
- Carlisle city council, Green Spaces Department.
- Carlisle city council, Planning Department.

On 28th January 2021, the Action Plan 2021 was presented to the Carlisle City Council Executive Committee, as part of the approval and consultation process with key stakeholders.

Each year the ASR is taken for consideration to the Health and Wellbeing Overview and Scrutiny Committee.

This ASR has been approved by the Principal Health and Housing Officer.

This ASR has not been signed off by a Director of Public Health.

If you have any comments on this ASR please send them to Environmental Health at:

Environmental Health, Governance and Regulatory Services, Civic Centre, Rickergate, Carlisle, CA3 8QG

01228 817000

environmentalhealth@carlisle.gov.uk

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1 Local Air Quality Management

This report provides an overview of air quality in Carlisle City Council during 2021. It fulfils the requirements of Local Air Quality Management (LAQM) as set out in Part IV of the Environment Act (1995) and the relevant Policy and Technical Guidance documents.

The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where an exceedance is considered likely the local authority must declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives. This Annual Status Report (ASR) is an annual requirement showing the strategies employed by Carlisle City Council to improve air quality and any progress that has been made.

The statutory air quality objectives applicable to LAQM in England are presented in Table E.1.

2 Actions to Improve Air Quality

Air Quality Management Areas

Air Quality Management Areas (AQMAs) are declared when there is an exceedance or likely exceedance of an air quality objective. After declaration, the authority should prepare an Air Quality Action Plan (AQAP) within 12 months setting out measures it intends to put in place in pursuit of compliance with the objectives.

A summary of AQMAs declared by Carlisle City Council can be found in Table 2.1. The table presents a description of the four AQMAs that are currently designated within Carlisle City Council. Appendix D: Map(s) of Monitoring Locations and AQMAs provides maps of AQMAs and also the air quality monitoring locations in relation to the AQMAs. The air quality objectives pertinent to the current AQMA designations are as follows:

- NO_2 annual mean;

Table 2.1 – Declared Air Quality Management Areas

AQMA Name	Date of Declaration	Pollutants and Air Quality Objectives	One Line Description	Is air quality in the AQMA influenced by roads controlled by Highways England?	Level of Exceedance: Declaration	Level of Exceedance: Current Year	Name and Date of AQAP Publication	Web Link to AQAP
AQMA 1	02/12/2005 Amended 25th July 2019	NO_2 Annual Mean	AQMA 1 Amended 25th July 2019 to include just 100 m Section along B6264 Brampton Road.	YES	45.3	26.9	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Residents/Environmental-Problems/Pollution-and-Air-Quality
AQMA 2	26/01/2007	NO_2 Annual Mean	AQMA 2 Currock Street and the properties immediately to the west of it, between the junction with James St/Water St and Crown St.	YES/NO	44.6	30.4	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Residents/Environmental-Problems/Pollution-and-Air-Quality
AQMA 3	01/08/2008 Revoked 3rd July 2019	NO_2 Annual Mean	AQMA 3 Wigton Road between Crummock Street and Caldewgate roundabout as well as properties on Caldcotes.	N/A	40	N/A	N/A	N/A

AQMA 4	01/08/2008	NO_2 Annual Mean	AQMA 4 North side of the A595 at Bridge Street, northbound from the junction with Shaddongate.	YES	43.9	36.3	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Residents/Environmental-Problems/Pollution-and-Air-Quality
AQMA 5	01/08/2008	NO_2 Annual Mean	AQMA 5 Junction of Dalston Road and Junction Street	YES/NO	48	32.9	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Residents/Environmental-Problems/Pollution-and-Air-Quality
AQMA 6	01/08/2008 Revoked 3rd July 2019	NO_2 Annual Mean	AQMA 6 London Road and properties on either side near the junction with Blake Street	N/A	43.3	N/A	N/A	N/A

☒ **Carlisle City Council confirm the information on UK-Air regarding their AQMA(s) is up to date.**

☒ **Carlisle City Council confirm that all current AQAPs have been submitted to Defra.**

Progress and Impact of Measures to address Air Quality in Carlisle City Council

Defra's appraisal of last year's ASR contained positive feedback, an issue was raised relating to the content of the report, as follows:

- *The Council should ensure that any text from the template is removed before submission of the report, such as text in red below Table 2-1.* This issue has been addressed in this ASR and any red advisory text from the template document has been removed.

Carlisle City Council has taken forward a number of direct measures during the current reporting year of 2021 in pursuit of improving local air quality. Details of all measures completed, in progress or planned are set out in Table 2.2. Twelve measures are included within Table 2.2, in line with our updated Action Plan 2021. The type of measure and the progress Carlisle City Council have made during the reporting year of 2021 are presented. Where there have been, or continue to be, barriers restricting the implementation of the measure, these are also presented within Table 2.2.

More detail on these measures can be found in Action Plan 2021.

Key completed measures are:

- Completion of the Carlisle Northern Development Route;
- Ongoing work to minimise emissions from domestic and industrial sources.
- Provision of home improvement grants to improve energy efficiency.
- Improved cycling and walking routes.

The updated Action Plan showed that the NOx emissions from Bridge Street needs to reduce by just 2.7 % to achieve compliance. Source apportionment showed that emissions from diesel vehicles dominated NOx emissions. A breakdown in NOx emissions, in terms of vehicle types, is as follows:

- Rigid HGVs 33.8 %;
- Diesel Cars 26.8 %;
- Buses/Coaches 13.7 %;
- Artic HGVs 12.4 %;
- Diesel LGVs 9.4 %;

- Petrol Cars 3.2 %;
- Motorcycles 0.30 %;
- Hybrids 0.29 %
- Petrol LGVs 0.02 %

Clearly reducing the proportion of diesel vehicles on Bridge Street would reduce NOx emissions. Increasing traffic flow through the traffic lights would also be beneficial.

The impact of increasing traffic speed on oxide of nitrogen emissions was investigated using the emission factor toolkit (EFT2019_v9.0)[10]. Traffic speeds were increased at 5 kph increments within the same model domain considered in the Air Quality Action Plan[11]. For the base case, NOx emissions were calculated to be 15.2 tonnes. Increasing the speed by 5 kph would cause a reduction of 17 % in NOx emissions easily exceeding the 2.7 % reduction required to achieve compliance of 40 µg m^{-3}. Emissions at the other speeds are given below:

	NOx emissions, tonnes / year	Percentage reduction, %
Base	15.2	
Base + 5 kph	12.7	17.0
Base + 10 kph	11.0	27.9
Base + 15 kph	9.9	35.1

Carlisle City Council will work with partners to implement actions to improve traffic flow along Bridge Street (AQMA 4). This future project will involve an application to secure some grant funding from Defra.

Carlisle City Council expects the following measures to be completed over the course of the next reporting year:

- Improve signalling to reduce standing and stop and start traffic at the pedestrian crossing on Bridge Street.

[10] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

[11] The Air Quality Action Plan has been updated as a draft and is currently under review by the Steering Body.

- Further progress on the Carlisle Southern Link Road: This will connect Junction 42 of the M6 with the A595 to the west.

Carlisle City Council's priorities for the coming year are to:

- Continue to work with the planning department to ensure air quality implications are taken into account in the planning process.
- Improve cycle links
- Signal improvements to improve traffic flow at traffic lights on Bridge Street
- Further progress on the Carlisle Southern Link Road: This will connect Junction 42 of the M6 with the A595 to the west.

The principal challenges and barriers to implementation that Carlisle City Council anticipates facing is the bus fleet not being ungraded, as the decision to invest in the fleet would be made by commercial operators.

Progress on the following measures has been slower than expected due to budget and time constraints:

- Public promotion of air quality
- The implementation of a 'Transport Overview and Joint Parking Policy' has been abandoned.

Carlisle City Council anticipates that the measures stated above and in Table 2.2 will achieve compliance in AQMA 4.

Table 2.2 – Progress on Measures to Improve Air Quality

Measure No.	Measure	Category	Classification	Year Measure Introduced	Estimated / Actual Completion Year	Organisations Involved	Funding Source	Defra AQ Grant Funding	Funding Status	Estimated Cost of Measure	Measure Status	Reduction in Pollutant / Emission from Measure	Key Performance Indicator	Progress to Date	Comments / Barriers to Implementation
1	Construction of the new Carlisle Southern Link Road (CSLR). This will extend the existing Carlisle Northern Development Route (CNDR). Monitor the air quality impacts of the CSLR and CNDR.	Traffic Management	Other	2010	2012	Cumbria County Council & Carlisle City Council	£158m of PFI funding	No	Complete	£158m of PFI funding	Complete	Anticipate approx. 25% reduction in NO2 in city centre.	Reduced NO2 levels at monitoring locations and within AQMA's.	The CNDR is operational. Monitoring at receptors on new road revealed consistently low NO2 levels. There is evidence of NO2 improvements and traffic reduction in the city centre. Several new cycle links from arterial routes to CNDR are complete. Environmental Health have provided a consultation response in relation to CSLR and have requested that an Air Quality Impact Assessment was carried out. Initial preparation works have begun on the new road but face delays due to supply and resource issues.	Plans to extend route via Carlisle Southern Link Road
2	Effective traffic management measures will be implemented to improve traffic flow on the existing road network and in new developments.	Traffic Management	UTC, Congestion management, traffic reduction	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget. Defra grant	Possible future grant application	Possible future grant application	Unknown. Currently investigating options.	Ongoing	Not calculated. See above for modelling undertaken at Bridge Street AQMA.	Reduced NO2 levels and standing traffic within AQMA's.	Traffic modelling has shown that emissions from diesel vehicles dominate emissions. Emissions factor toolkit has been used to show increased traffic speeds would reduce oxide of nitrogen emissions within Bridge Street. Work will continue to improve traffic management in this area. Plans to apply for Defra grant.	Requires significant investment
3	Environmental Health will work alongside the Planning Department to minimise the air quality impacts of new developments.	Policy Guidance and Development Control	Air Quality Planning and Policy Guidance	Ongoing	Ongoing	Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Improved links between EH and Planning. AQIA's submitted as necessary. Early consultation with applicants.	Environmental Health is consulted on all proposed developments which may impact on air quality. Responses are aimed at minimising AQ impacts, particularly within or close to our AQMA's. This includes large residential developments. Recommendations made for car charging points for all new residential properties.	Environmental Health comment on all potentially polluting developments
4	Improvements to passenger transport infrastructure. Sustainable transport will be integrated into major new developments	Transport Planning and Infrastructure	Bus route improvements	Ongoing	Ongoing	Cumbria County Council	Commercial investment from bus companies and County Council Highway projects.	No	ongoing	Unknown. Ongoing works	Ongoing	Not calculated	Improved bus service. Increased use of transport provided. Reduced NO2 along main routes	Ongoing improvements to bus services with new shelters and raised kerbs. Plans for large new housing developments include public transport provision and/or sustainable transport options. .	Success is dependent on public uptake of sustainable transport options. No real control over the improvement of vehicle fleet.
5	Cycling and walking will be encouraged. Implement new and improved pedestrian and cycle links	Transport Planning and Infrastructure	Cycle network	Ongoing	Ongoing	Cumbria County Council	Various grant schemes and S106 agreements	No	Ongoing	Unknown. Ongoing projects and funding applications from various sources	Ongoing	Not calculated	Completion of proposed works and ongoing improvement of the cycle and pedestrian route network.	Extensive plans to increase the cycle path network are in place and installing vehicle charging points. The Local Cycling and Walking Infrastructure Plans (LCWIPs) identify and prioritise cycling and walking improvements at a local level. The council is now working with partners to secure funding. Active Travel Social Prescribing for Carlisle and Barrow Council has been awarded £1.5m of funding. It will Establish a series of Active Travel Events - educating a wider audience on ways to get more active, provide e-bikes, adaptable bikes, implement hire and loan cycle schemes and enhance cycle parking in places like leisure centres, retail outlets, central hubs, health settings, and schools. A new Cumbria wide EV Charging Infrastructure Partnership has been	Ongoing plans associated with improved pedestrian and cycle connections to the CNDR.

														formed through The One Public Estate (OPE) programme. The Electric Vehicle Charging Infrastructure Partnership is a group of organisations from across Cumbria, who are working together to deliver a co-ordinated approach to addressing the future Electric Vehicle charging needs of the county	
6	Travel plans will be required for all new developments that meet the criteria. Existing businesses will be encouraged to implement, monitor and review travel plans.	Promoting Travel Alternatives	Workplace Travel Planning	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increased number of participant businesses and more widespread use of alternative transport.	All schools within the city now have travel plans. New developments likely to result in increased highway usage must submit a travel plan for approval when making an application. Any funding from developers is now passed to the County Council to assess and monitor travel plans.	Difficult to quantify the impact of Travel Plans
7	The City Council will continue to provide comprehensive environmental control over emissions from all Part A2 and B Processes located within the local authority area.	Environmental Permits	Other measure through permit systems and economic instruments	Ongoing	Ongoing	Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Risk based inspections showing that emission limits are being met and efforts are being made to improve on national objectives.	All processes which fall under part B & A2 processes are permitted by Carlisle CC. No recent enforcement action required in relation to emissions.	No new major polluting processes in previous year.
8	The City Council will continue to investigate complaints of black smoke and smoke nuisance as well as managing smokeless zones. Enforcement action will be taken as necessary.	Public Information	Other	Ongoing	Ongoing	Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Reduction in the number of complaints from members of the public. Reduction in repeat offenders.	There is information on website. Environmental Health provide advice and enforcement as required. Smoke complaints are responded to involving domestic fires, bonfires, trade waste, industrial and dark smoke. Advice leaflet sent out for all cases of domestic burning. Advice given to minimise potential for smoke issues and ensure compliance with smokeless zones.	The Air Quality Strategy set out a goal to cut public exposure to particulate matter pollution. This measure will contribute to this target.
9	Provision of home improvement grants and energy saving advice to the public.	Public Information	Other	Ongoing	Ongoing	Carlisle City Council	Through government grant schemes and energy providers	No	Funding secured for current schemes	Depends on uptake and grant schemes available	Ongoing	Cumbria Warm Homes Project (CWHP) delivered a reduction of 317296 lifetime carbon tonnes.	Number of properties taking up schemes, resulting in Improved energy efficiency of housing stock.	Carlisle CC Home Improvement Agency is currently delivering Health through Warmth Scheme, supported by the Energy Companies Obligation. This includes boiler upgrades and home insulation. Grants provided by the council enable low income homes to carry out minor repairs and home energy efficiency measures. A bid from the 6 district councils to the Local Authority Delivery Phase 3 (LAD3) and Home Upgrade Grant Phase 1 (HUG1) funds has led to the formation of Cumbrian Sustainable Warmth consortium. The consortium aims to address fuel poverty, improve energy efficiency and carbon savings and has received £19,955,000 funding from the UK Government. Carlisle is one of 28 locations taking part in a Heat Network Zone Pilot. The pilot is gathering data from stakeholders that have high amount of heat waste that they could donate to a heat network.	Carlisle CC have revised Housing Renewal Assistance Policy under the Regulatory Reform Order 2002. This covers all grants involving housing and energy efficiency measures.
10	Environmental Health will work alongside the Neighbourhoods and Green Spaces team to implement the effective use of trees and green areas to offset traffic derived emissions.	Public Information	Other	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increase in trees and vegetation in visible locations. Increased public interest.	Carlisle City Council continues to manage and maintain trees in parks and green spaces, including some additional planting, of mainly mixed broadleaf species, where necessary. Planting of green areas is an essential part of many new developments, including residential.	Limitations to planting options in busy urban areas. Parks and open spaces do not have significant air quality issues. Green Spaces continue to have a positive public impact

11	Air Quality considerations to be included in all relevant City and County Council policies and strategies..	Policy Guidance and Developme nt Control	Air Quality Planning and Policy Guidance	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increased awareness of air quality issues and consideration given by more council departments.	Included air quality links within most major relevant policies including Local Transport Plan (LTP 3) (2011-26) and The Carlisle District Local Plan (2015-30). New schemes are being developed to deliver improved cycling routes and vehicle charging infrastructure.	Air Quality considerations are put forward during discussion and consultation stages of policy development.
12	Promotion of air quality and sustainable transport issues. Air quality information and monitoring data will be provided to the public.	Public Information	via the Internet	Ongoing	Ongoing	Carlisle City Council/ PH	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increased public awareness and participation in improving air quality.	Air quality info and real time monitoring data is available on the website. Monitoring data shows continued improvement in most areas. Carlisle CC is actively supporting and promoting Clean Air Day, utilising social media and our website, as part of the Global Action Plan. Cumbria' County Council has ongoing projects to cut carbon emissions in the county. These aim to raise ambition to tackle climate change and sharing learning and resources. Defra grant application will include increased public engagement and information provision, via website, local and social media.	Difficult to quantify any improvement as a direct result of promotional work or providing monitoring data.

$PM_{2.5}$ – Local Authority Approach to Reducing Emissions and/or Concentrations

As detailed in Policy Guidance LAQM.PG16 (Chapter 7), local authorities are expected to work towards reducing emissions and/or concentrations of $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5µm or less). There is clear evidence that $PM_{2.5}$ has a significant impact on human health, including premature mortality, allergic reactions, and cardiovascular diseases.

Carlisle City Council is taking the following measures to address $PM_{2.5}$:

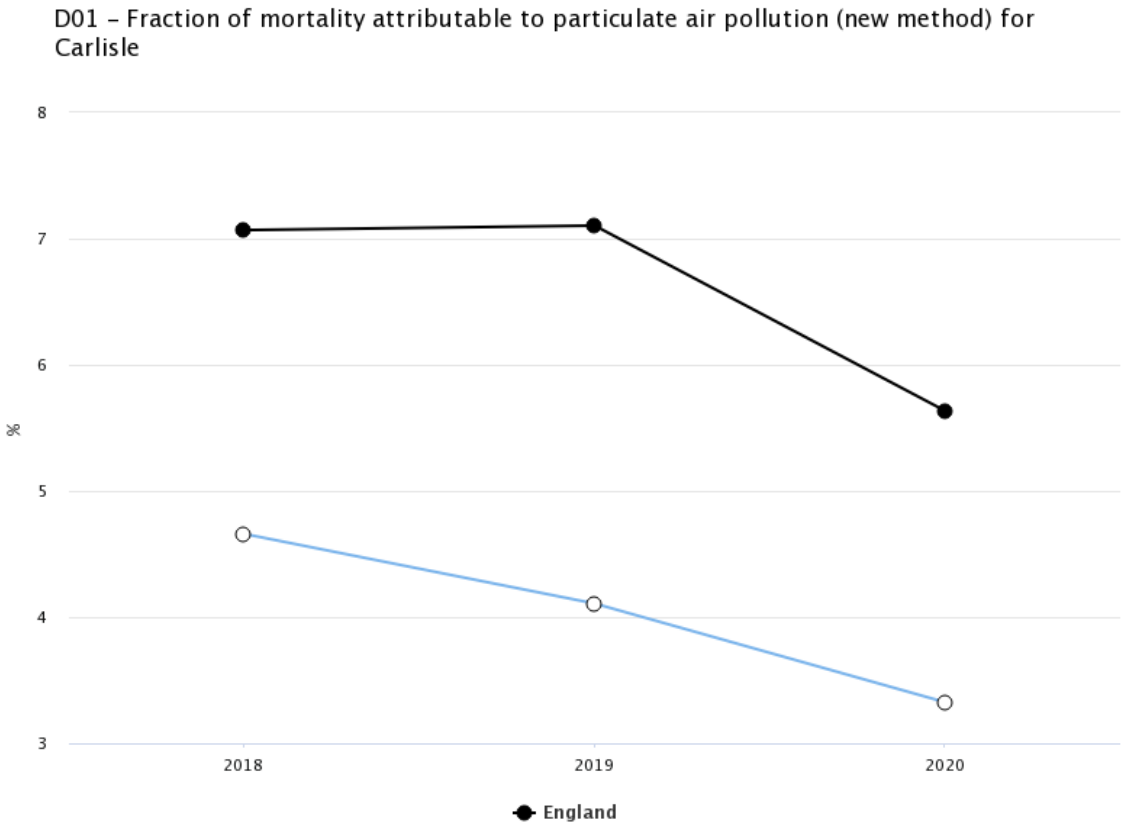
- Carlisle City Council has monitored $PM_{2.5}$ levels at Paddy's Market AQMS since 2009 as part of the AURN. This is a busy city centre junction between two AQMA's. The annual mean concentrations are consistently well below the objective at around 8-11 µg m^3 at this location (see Figure A.8), however ongoing efforts are being made to reduce these levels. The automatic analysers has now been moved to Morton Community Centre.
- Carlisle City Council will continue to work in partnership with Cumbria County Council as the highways authority and also in relation to any planning applications with significant air quality implications. The Environmental Health department will continue to work with the City Council Planning Department with regard to new local developments and ensure that air quality implications and mitigation measures are taken into consideration in the planning process.
- We will continue to work alongside the Neighbourhoods and Green Spaces team to investigate and implement the effective use of trees and green areas to offset traffic derived emissions in existing AQMA's and in new development areas.
- The City Council will also continue to provide comprehensive control over emissions from all Part A2 and B Processes located within the local authority area. We will work closely with the operators of these installations to continuously monitor and improve on their emissions to air as part of the permitting process. In line with measures 2, 3, 6, 8, 11 and 12 of the above Action Plan.

Carlisle City Council has four designated smoke control areas. The locations of the smoke control areas within Carlisle are highlighted on our online mapping tool (http://maps.carlisle.gov.uk/MyCarlisle.aspx) or can be downloaded as a map

(http://www.carlisle.gov.uk/LinkClick.aspx?fileticket=9E67HYHexDw%3d&tabid=729&portalid=0&mid=2838).

The most recent available data from Public Health England's Public Health Outcomes Framework[12] show that the fraction of total mortality which is attributable to particulate air pollution within Carlisle City Council was 3.3 % in 2020 (the most recent data available). This is below the average for both the North West (5.0%) and England as a whole (5.6%)

Figure 2–1 Fraction of mortality attributed to particulate air pollution in Carlisle City Council (blue line)



12 https://fingertips.phe.org.uk/profile/public-health-outcomes-framework/data#page/4/gid/1000043/pat/6/par/E12000002/ati/401/are/E07000028/iid/93861/age/230/sex/4/cat/-1/ctp/-1/yrr/1/cid/4/tbm/1/page-options/ovw-do-0

Note, The method for calculating the fraction of mortality attributable to particulate air pollution was updated in 2022.

3 Air Quality Monitoring Data and Comparison with Air Quality Objectives and National Compliance

This section sets out the monitoring undertaken within 2021 by Carlisle City Council and how it compares with the relevant air quality objectives. In addition, monitoring results are presented for a five-year period between 2017 and 2021 to allow monitoring trends to be identified and discussed.

Summary of Monitoring Undertaken

3.1.1 Automatic Monitoring Sites

Carlisle City Council undertook automatic (continuous) monitoring within Paddy's Market[13] until 21st June 2021. The monitor equipment was relocated some 1.6 km west along the A595 to a new site within the carpark at the Morton Community Centre[14]. This site began automatic monitoring of nitrogen dioxide, $PM_{2.5}$ and PM_{10} from 1st October 2021.

Table A.1 in Appendix A shows the details of the automatic monitoring sites. NB. Local authorities do not have to report annually on the following pollutants: 1,3 butadiene, benzene, carbon monoxide and lead, unless local circumstances indicate there is a problem. Automatic monitoring results are available through the UK-Air website (https://uk-air.defra.gov.uk/data/data_selector)

Maps showing the location of the monitoring sites are provided in Appendix D. Further details on how the monitors are calibrated and how the data has been adjusted are included in Appendix C.

3.1.2 Non-Automatic Monitoring Sites

Carlisle City Council undertook non- automatic (i.e. passive) monitoring of NO_2 at twenty nine sites during 2021. Sampling took place for the first five months at Paddy's Market

[13] This site also formed part of Defra's compliance monitoring network in which it was known as Carlisle Roadside.

[14] This site is known as Carlisle Morton A595 within Defra's compliance monitoring network

(E6) after which time the monitoring site was relocated to Morton Community Centre (H9) where sampling began in August 2021 (5 months in total). Hence, annualisation of the annual mean was required at both sites (see Table C.1).

Table A.2 in Appendix A presents the details of the non-automatic sites.

Maps showing the location of the monitoring sites are provided in Appendix D. Further details on Quality Assurance/Quality Control (QA/QC) for the diffusion tubes, including bias adjustments and any other adjustments applied (e.g. annualisation and/or distance correction), are included in Appendix C.

Individual Pollutants

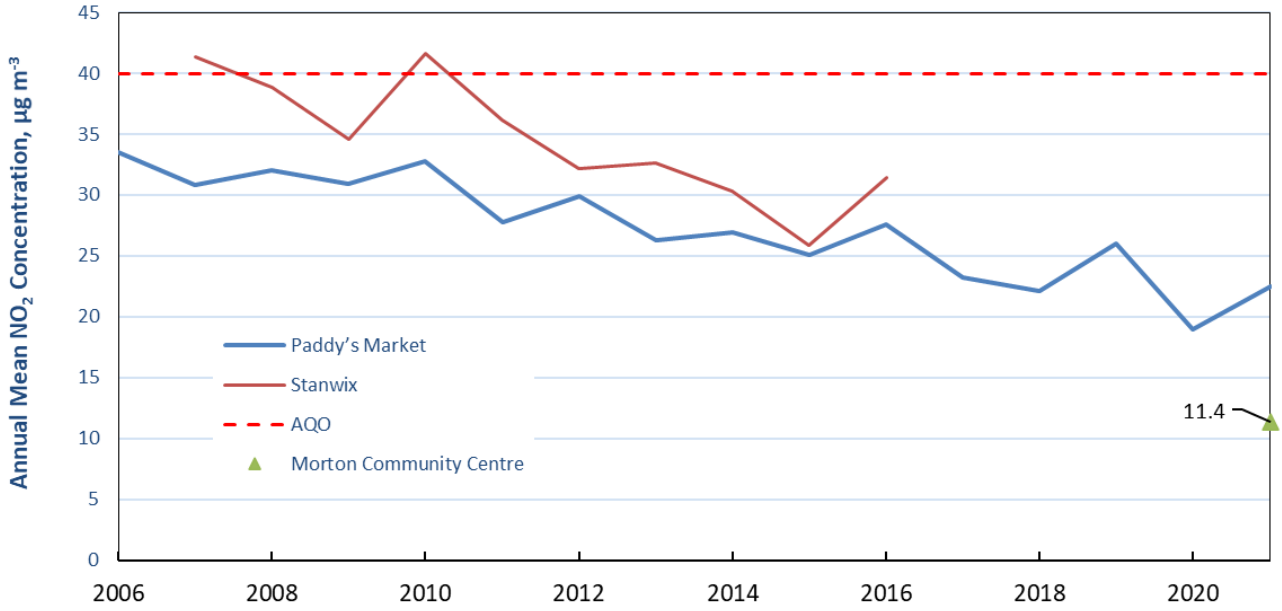
The air quality monitoring results presented in this section are, where relevant, adjusted for bias, annualisation (where the annual mean data capture is below 75% and greater than 25%), and distance correction. Further details on adjustments are provided in Appendix C.

3.1.3 Nitrogen Dioxide (NO_2)

Automatic monitoring of nitrogen dioxide concentrations began in 2006 at Paddy's Market (PM1) and stopped in June 2021. The automatic instruments were relocated to the car park of the Morton Community Centre and sampling began 1st October 2021. The relocation of the automatic monitoring station also meant that the annual mean concentrations required annualisation. For Paddy's Market, the annual data capture was 46.5 % and hence within the permissible data capture range. However, the annual data capture at Morton Community Centre was 18.9 % so outside the permissible range for annualisation. The annual concentration at this site is provided for indicative purposes only.

Also, automatic monitoring began at Stanwix Bank in 2007 and finished in 2016. Figure 3-1 compares the annual mean concentration at each site with the annual mean objective concentration. Monitored NO_2 concentrations at the automatic monitoring stations have been consistently below the objective concentrations since 2011.

Figure 3-1 Automatic monitoring data (2006 – 2021)



Error! Reference source not found. (automatic monitoring) and **Error! Reference source not found.** (diffusion tubes) in Appendix A present the ratified and adjusted monitored NO_2 annual mean concentrations for the past five years. Note that the concentration data presented represents the concentration at the location of the monitoring site, following the application of bias adjustment and annualisation, as required (i.e. the values are exclusive of any consideration to fall-off with distance adjustment).

The annual mean concentrations are compared with the air quality objective of 40 µg m^{-3} in Figures A.1 to A.5. In each case, the NO_2 concentrations are greater than those measured in 2020 but have not yet matched the concentrations measured in 2019.

Figure A.1 shows the NO_2 concentrations measured by the automatic monitor at Paddy's Market for all years since 2006. The concentration increased to 22.5 µg m^{-3} from the 19.0 µg m^{-3} measured in 2020 and is similar to the four year average for 2017 to 2020 (22.6 µg m^{-3}). Concentrations remained significantly below the air quality objective. Also, presented is the annual mean NO_2 concentration (11.4 µg m^{-3}) measured at Morton Community Centre. This is about half the NO_2 concentration measured at Paddy's Market and probably reflects the lower NOx emissions in this part of the city.

For sites situated along the A7 (see Figure A.2), the highest concentration (30.5 µg m^{-3}) was measured at Stanwix Bank (A10) which represented an increase of 5.6 µg m^{-3} compared to what was measured in 2020.

For sites within AQMA 2 (Currock Street, B7) and AQMA 5 (Dalston Road, B4) NO_2 and in the city centre, NO_2 concentrations also increased (see Figure A.3). Within AQMA 2 and AQMA 5, the NO_2 concentrations increased by 3.5 µg m^{-3} and 4.6 µg m^{-3}, respectively compared to what was measured in 2020.

For sites situated along the section of Wigton Road closer to the city centre and Bridge Street (see Figure A.4) the highest concentration (36.3 µg m^{-3}) continues to be measured in AQMA 4 Bridge Street (E8). The highest absolute increase in concentration (7.1 µg m^{-3}) occurred at 49 Wigton Road (E19) where the concentrations increased from 22.3 µg m^{-3} in 2020 to 29.4 µg m^{-3} in 2021.

The remaining sites situated along London Road (including revoked AQMA 6), along the Carlisle Northern Development Route and at a number of locations to the south of city centre and at the airport also showed a small increase in NO_2 concentration (see Figure A.5). The new site at Morton Community Centre H9 measured a NO_2 concentration of 10.6 µg m^{-3} slightly less concentration measured at Site H6 (12.0 µg m^{-3}) also on Wigton Road.

For diffusion tubes, the full 2021 dataset of monthly mean values is provided in Appendix B. Note that the concentration data presented in Table B.1 includes distance corrected values, only where relevant.

Error! Reference source not found. in Appendix A compares the ratified continuous monitored NO_2 hourly mean concentrations for the past five years with the air quality objective of 200 µg m^{-3}, not to be exceeded more than 18 times per year. There were no exceedances of the hourly mean concentration in 2021.

Table 3-1 presents the annual mean concentrations measured at monitoring stations within the current AQMAs. Recommendations for retaining, amending or revoking the AQMA's are also presented in Table 3-1. In each case concentrations increased in 2021 compared to 2020. Monitoring should continue before decisions on amending or revocation can be made with confidence.

Table 3-1 – Nitrogen dioxide concentrations measured by diffusion tube within each air quality management area

Site ID	Site Name		NO_2 Annual Mean Concentration ($\mu g/m^3$)							Recommendation
		AQMA	2015	2016	2017	2018	2019	2020	2021	
A9	AQMA 1 BRAMPTON RD	1	35.9	37.4	35.5	32.4	32.7	23.0	26.9	No exceedances of annual objective within AQMA 1 since 2013. Consider revocation if low concentrations remain. ***Keep AQMA***
B7	AQMA 2 CURROCK ST	2	36.5	37.7	37.0	35.2	38.1	27.0	30.4	While no exceedances measured in last six years, concentrations before 2020 concentrations were sufficiently high to suggest there may be a risk of exceedance in future years ***Keep AQMA***
B4	AQMA 5 DALSTON RD	5	41.0	40.0	39.9	35.8	38.7	28.3	32.9	While no exceedances measured in last five years, concentrations before 2020 concentrations were sufficiently high to suggest there may be a risk of exceedance in future years ***Keep AQMA***
E8	AQMA 4 BRIDGE ST	4	41.2	41.5	44.9	40.8	42.7	31.7	36.3	Likely to exceed in 2022. ***Keep AQMA***

3.1.4 Particulate Matter (PM_{10})

Table A.6 in Appendix A: Monitoring Results compares the ratified and adjusted monitored PM_{10} annual mean concentrations for the past five years with the air quality objective of 40 µg m^{-3}.

Table A.7 in Appendix A compares the ratified continuous monitored PM_{10} daily mean concentrations for the past five years with the air quality objective of 50 µg m^{-3}, not to be exceeded more than 35 times per year.
As the annual data capture was 45.2 % annualisation was required. Further details can be found in Table C.4. The PM_{10} annualised annual mean concentration monitored by the Paddy's Market automatic analyser was 17.2 µg m^{-3} in 2021 and hence significantly below the annual mean AQO of 40 µg m^{-3}.

There were also no exceedances of the short-term AQOs. The five year trend is for both air quality objectives are shown in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively.

The PM_{10} annual mean concentration at Morton Community Centre was 11.5 µg m^{-3}. As the annual data capture was less than 25 %, annualisation is not recommended and annual mean concentration should be regarded as an indicative value.

3.1.5 Particulate Matter ($PM_{2.5}$)

Table A.8 in Appendix A presents the ratified and adjusted monitored $PM_{2.5}$ annual mean concentrations for the past five years.

$PM_{2.5}$ is the pollutant which has the biggest impact on public health and on which the Public Health Outcomes Framework (PHOF) indicator is based. Therefore, although not covered by the LAQM regulations, local authorities are encouraged to understand the $PM_{2.5}$ concentration within their council area. The annualised annual mean was 9.4 µg m^{-3} which is lower than the World Health Organisation guideline of 10 µg m^{-3}. Elsewhere, the background $PM_{2.5}$ maps[15] for Carlisle City Council for 2021 showed no guideline concentration.

[15] https://uk-air.defra.gov.uk/data/laqm-background-home

The $PM_{2.5}$ annual mean concentration at Morton Community Centre was 8.8 µg m^{-3}. As the annual data capture was less than 25 %, annualisation is not recommended and annual mean concentration should be regarded as an indicative value.

Carlisle City Council also acknowledges Defra's proposed Environmental Targets for $PM_{2.5}$.

- Annual mean concentration target – 10 µg m^{-3} to be achieved by 2040
- Population Exposure Reduction Target – 35% reduction (on 2018 baseline) by 2040

The Government expects local authorities will need to take actions in support of the new targets.

Appendix A: Monitoring Results

Table A.1 – Details of Automatic Monitoring Sites

Site ID	Site Name	Site Type	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Pollutants Monitored	In AQMA? Which AQMA?	Monitoring Technique	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Inlet Height (m)
PM1	Paddy's Market	Roadside	339467	555974	NO_2	NO	Chemiluminescence	42	4	2.8
PM1	Paddy's Market	Roadside	339467	555974	PM_{10}	NO	BAM 1020 heated	42	4	2.8
PM1	Paddy's Market	Roadside	339467	555974	$PM_{2.5}$	NO	BAM 1020 heated	42	4	2.8
MCC 1	Morton CCC	Roadside	338195	554990	NO_2	NO	Chemiluminescence	6	8	2.37
MCC 1	Morton	Roadside	338195	554990	PM_{10}	NO	BAM 1020 heated	6	8	2.67
MCC 1	Morton	Roadside	338195	554990	$PM_{2.5}$	NO	BAM 1020 heated	6	8	2.77

Notes:

(1) 0m if the monitoring site is at a location of exposure (e.g. installed on the façade of a residential property).

(2) N/A if not applicable

Table A.2 – Details of Non-Automatic Monitoring Sites

Diffusion Tube ID	Site Name	Site Type	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Pollutants Monitored	In AQMA? Which AQMA?	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Tube Co-located with a Continuous Analyser?	Tube Height (m)
A1	45 SCOTLAND RD	Roadside	339995	557188	NO_2	NO	4.5	1.5	NO	3.05
A10	STANWIX BANK	Roadside	340008	556842	NO_2	NO	1.5	1.5	NO	2.95
A12	STANWIX BANK CAR PARK	Roadside	339935	557125	NO_2	NO	0.0	3.0	NO	2.8
A5	37 KINGSTOWN RD	Roadside	339758	558059	NO_2	NO	0.0	4.0	NO	2.8
A7	282 KINGSTOWN RD	Roadside	339526	559285	NO_2	NO	7.5	4.0	NO	2.7
A9	BRAMPTON RD	Roadside	340028	556833	NO_2	Yes, AQMA 1	0.0	1.5	NO	2.75
B4	DALSTON RD	Roadside	339434	555638	NO_2	Yes, AQMA 5	0.0	3.5	NO	2.8
B7	12 CURROCK ST	Roadside	340205	555198	NO_2	Yes, AQMA 2	0.0	3.0	NO	3.05
C1	LOWTHER ST	Roadside	340216	556131	NO_2	NO	0.0	3.0	NO	2.85
C2	TOURIST INFO	Urban Centre	340069	555955	NO_2	NO	N/A	N/A	NO	2.7
C3	DEVONSHIRE ST	Roadside	340218	555768	NO_2	NO	0.0	3.0	NO	2.85
D12	POST OFFICE	Kerbside	340307	555718	NO_2	NO	N/A	5.0	NO	2.95
D7	282 WARWICK RD	Roadside	341593	555893	NO_2	NO	0.0	7.0	NO	2.8
E22	FINKLE ST	Roadside	339834	556137	NO_2	NO	0.0	12.0	NO	2.8
E12	3 WIGTON RD	Roadside	339225	555821	NO_2	NO	2.0	2.5	NO	2.95
E15	22 WIGTON RD	Roadside	339091	555736	NO_2	NO	0.0	4.5	NO	3.9
E16	JOVIAL SAILOR	Roadside	339141	555900	NO_2	NO	0.0	2.5	NO	2.7
E19	49 WIGTON RD	Roadside	338953	555610	NO_2	NO	0.0	2.5	NO	3.1
E6	PADDYS MARKET	Roadside	339467	555974	NO_2	NO	N/A	9.0	Yes	3
E8	BRIDGE ST	Roadside	339516	556024	NO_2	Yes, AQMA 4	0.0	4.0	NO	3.05
F10	155 BOTCHERGATE	Roadside	340600	555349	NO_2	NO	0.0	3.0	NO	2.7

Diffusion Tube ID	Site Name	Site Type	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Pollutants Monitored	In AQMA? Which AQMA?	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Tube Co-located with a Continuous Analyser?	Tube Height (m)
F7	24 LONDON RD	Roadside	340708	555240	NO_2	NO	0.0	4.5	NO	2.7
F9	129 LONDON RD	Kerbside	341099	554931	NO_2	NO	0.0	0.5	NO	2.95
G4	THE HOBBIT	Rural	336905	554036	NO_2	NO	0.0	19.0	NO	2.85
H5	WIGTON RD	Roadside	337643	554100	NO_2	NO	0.0	1.5	NO	2.4
H6	PETER LANE	Roadside	337962	553220	NO_2	NO	0.0	4.0	NO	2.4
H7	DALSTON RD	Roadside	338282	553396	NO_2	NO	0.0	6.5	NO	2.4
H8	AIRPORT	Other	347874	561254	NO_2	NO	0.0	2.0	NO	2.4
H9	Morton Community Centre	Roadside	338195	554990	NO_2	NO	6.0	8.0	Yes	2.4

Notes:

(1) 0m if the monitoring site is at a location of exposure (e.g. installed on the façade of a residential property).

(2) N/A if not applicable.

Table A.3 – Annual Mean NO_2 Monitoring Results: Automatic Monitoring (µg m^{-3})

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2021 (%) (2)	2017	2018	2019	2020	2021
PM1	339467	555974	Roadside	99.3	46.5	23.3	22.1	26	19	22.5
MCC 1	338195	554990	Roadside	78.6	19.8					11.4

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16.**

☒ **Reported concentrations are those at the location of the monitoring site (annualised, as required), i.e. prior to any fall-off with distance correction.**

Notes:

The annual mean concentrations are presented as µg m^{-3}.

Exceedances of the NO_2 annual mean objective of 40µg m^{-3} are shown in **bold**.

All means have been "annualised" as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Concentrations are those at the location of monitoring and not those following any fall-off with distance adjustment.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Table A.4 – Annual Mean NO_2 Monitoring Results: Non-Automatic Monitoring (µg m^{-3})

Diffusion Tube ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2021 (%) (2)	2017	2018	2019	2020	2021
A1	339995	557188	Roadside	92.7	92.7	31.7	30.1	31.7	23.3	25.5
A10	340008	556842	Roadside	83.5	83.5	36.4	37.6	36.7	24.9	30.5
A12	339935	557125	Roadside	85.1	85.1	28.6	28.2	28.7	20.8	24.3
A5	339758	558059	Roadside	92.7	92.7	32.5	29.2	31.5	21.4	25.2
A7	339526	559285	Roadside	84.9	84.9	23.4	21.2	20.7	14.1	17.1
A9	340028	556833	Roadside	92.7	92.7	35.5	32.4	32.7	23.0	26.9
B4	339434	555638	Roadside	92.7	92.7	39.9	35.8	38.7	28.3	32.9
B7	340205	555198	Roadside	92.7	92.7	37	35.2	38.1	27.0	30.4
C1	340216	556131	Roadside	92.7	92.7	27.2	27.4	27.6	19.7	22.1
C2	340069	555955	Urban Centre	92.7	92.7	19.3	20.2	17.8	11.5	13.2
C3	340218	555768	Roadside	92.7	92.7	25.5	24.4	27.5	18.6	22.8
D12	340307	555718	Kerbside	92.7	92.7	34.4	30.4	32.7	20.4	24.7
D7	341593	555893	Roadside	92.7	92.7	32.1	28	28.3	20.8	24.8
E22	339834	556137	Roadside	92.7	92.7	30.5	29.1	31.4	22.0	24.7
E12	339225	555821	Roadside	92.7	92.7	33.5	31.9	33.9	24.6	29.5
E15	339091	555736	Roadside	92.7	92.7	30.2	28.4	29.2	21.4	26.4
E16	339141	555900	Roadside	92.7	92.7	31.4	31.7	32	22.6	27.3
E19	338953	555610	Roadside	92.7	92.7	31.5	30.6	31.2	22.2	29.4
E6	339467	555974	Roadside	100.0	41.9	27.4	28.3	26.4	21.1	22.8
E8	339516	556024	Roadside	92.7	92.7	**44.9**	**40.8**	**42.7**	31.7	36.3

Diffusion Tube ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2021 (%) (2)	2017	2018	2019	2020	2021
F10	349597	555351	Roadside	92.7	92.7	36.3	35.3	34.4	25.4	29.9
F7	340708	555240	Roadside	92.7	92.7	33.8	32.2	35.4	24.7	31.0
F9	341099	554931	Kerbside	92.7	92.7	30.4	30.3	31.4	23.6	28.9
G4	336905	554036	Rural	92.7	92.7	12	12.6	12.1	8.0	9.5
H5	337643	554100	Roadside	92.7	92.7	16.6	15.7	14.1	10.4	12.0
H6	337962	553220	Roadside	92.7	92.7	9.4	11.4	10.1	8.4	8.4
H7	338282	553396	Roadside	92.7	92.7	15.1	18.7	15.1	11.6	13.2
H8	347874	561254	Other	85.1	85.1	7.5	8.2	6.9	4.8	5.5
H9	338195	554990	Roadside	85.3	43.2					10.6

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16**

☒ **Diffusion tube data has been bias adjusted.**

☒ **Reported concentrations are those at the location of the monitoring site (bias adjusted and annualised, as required), i.e. prior to any fall-off with distance correction.**

Notes:

The annual mean concentrations are presented as µg m^{-3}.

Exceedances of the NO_2 annual mean objective of 40 µg m^{-3} are shown in **bold**.

NO_2 annual means exceeding 60 µg m^{-3}, indicating a potential exceedance of the NO_2 1-hour mean objective are shown in **bold and underlined**.

Means for diffusion tubes have been corrected for bias. All means have been “annualised” as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Concentrations are those at the location of monitoring and not those following any fall-off with distance adjustment.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.1 – Trends in Annual Mean NO_2 Concentrations: Automatic monitoring at Paddy's Market

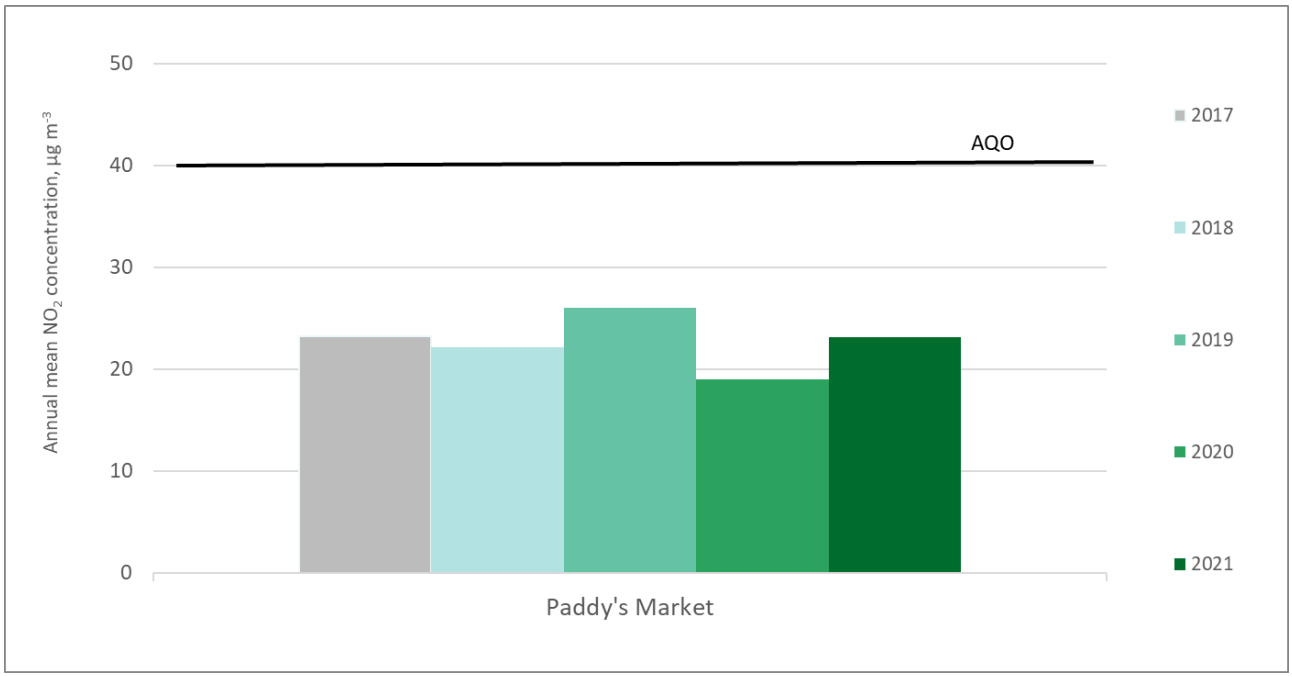


Figure A.2 – Trends in annual mean NO_2: along A7

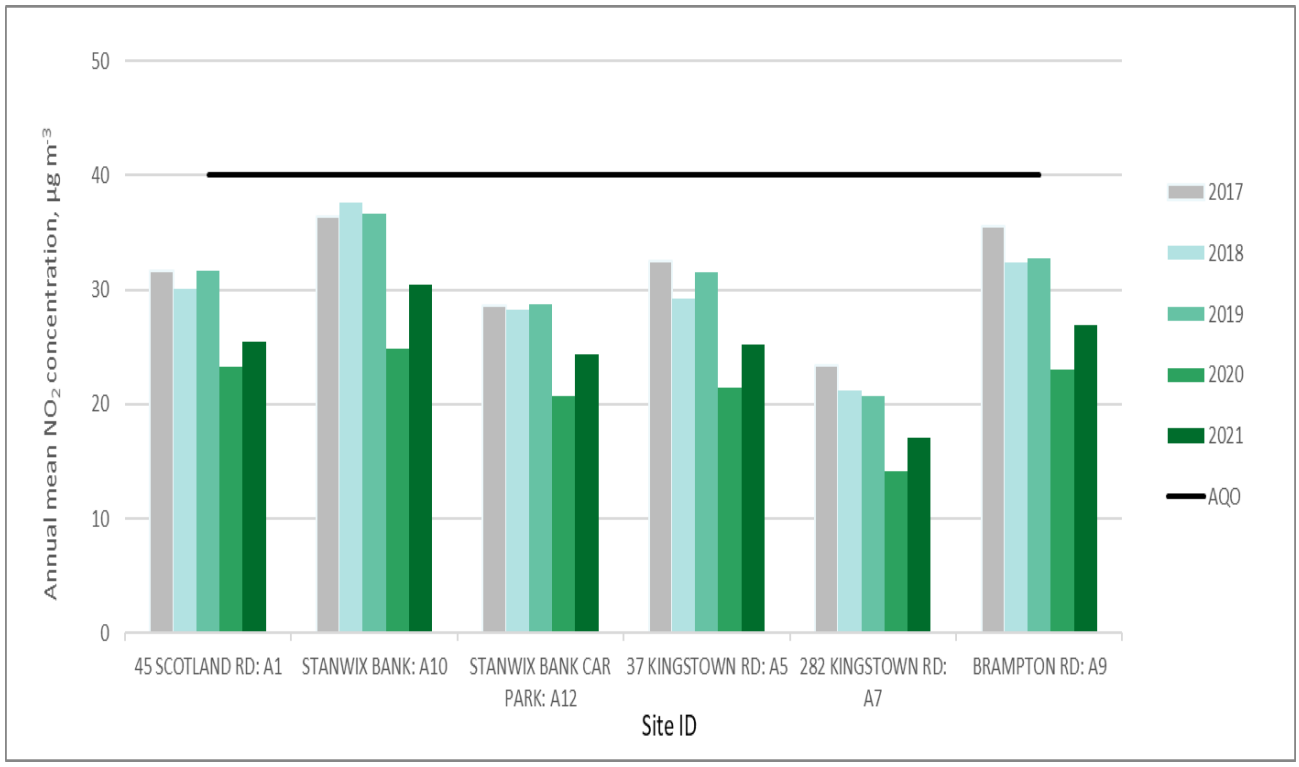


Figure A.3 – Trends in annual mean NO_2: for sites in city centre and within AQMA 2 and AQMA 5

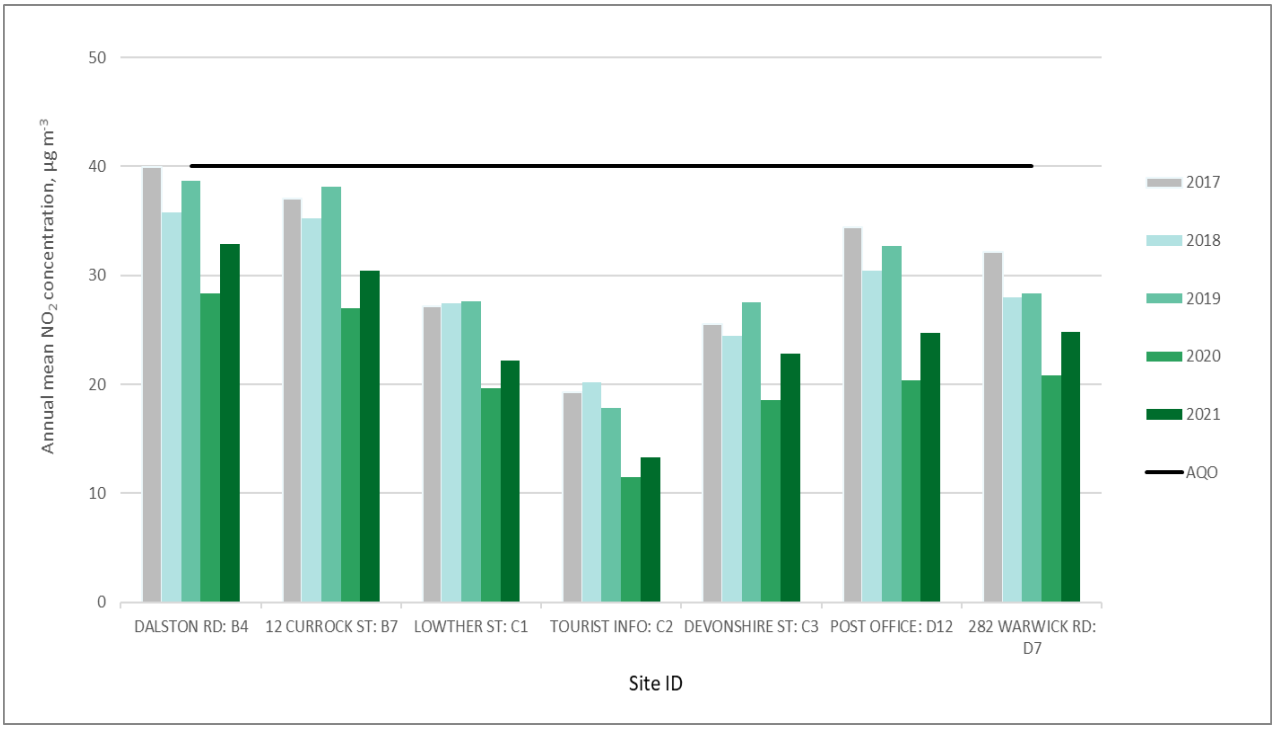


Figure A.4 – Trends in annual mean NO_2: along Wigton Road and Bridge Street

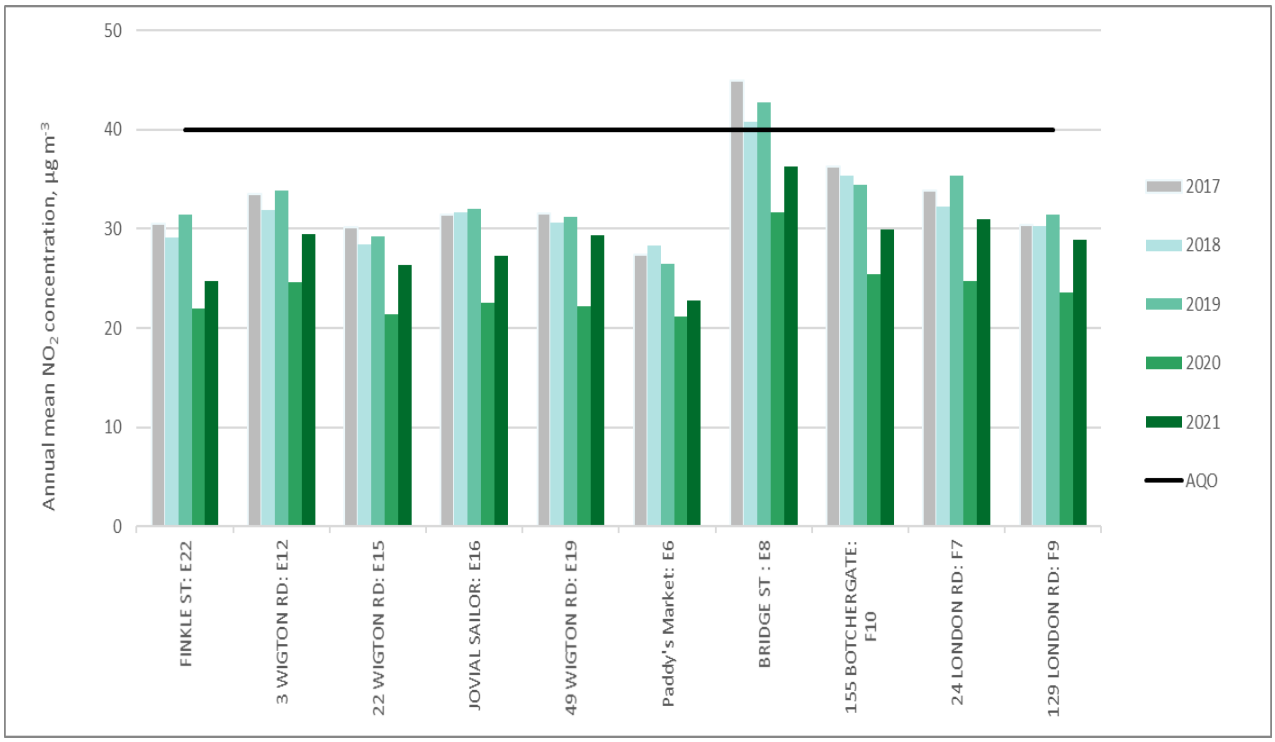


Figure A.5 – Trends in annual mean NO_2: at London Road, Carlisle Northern Development Route and various other locations

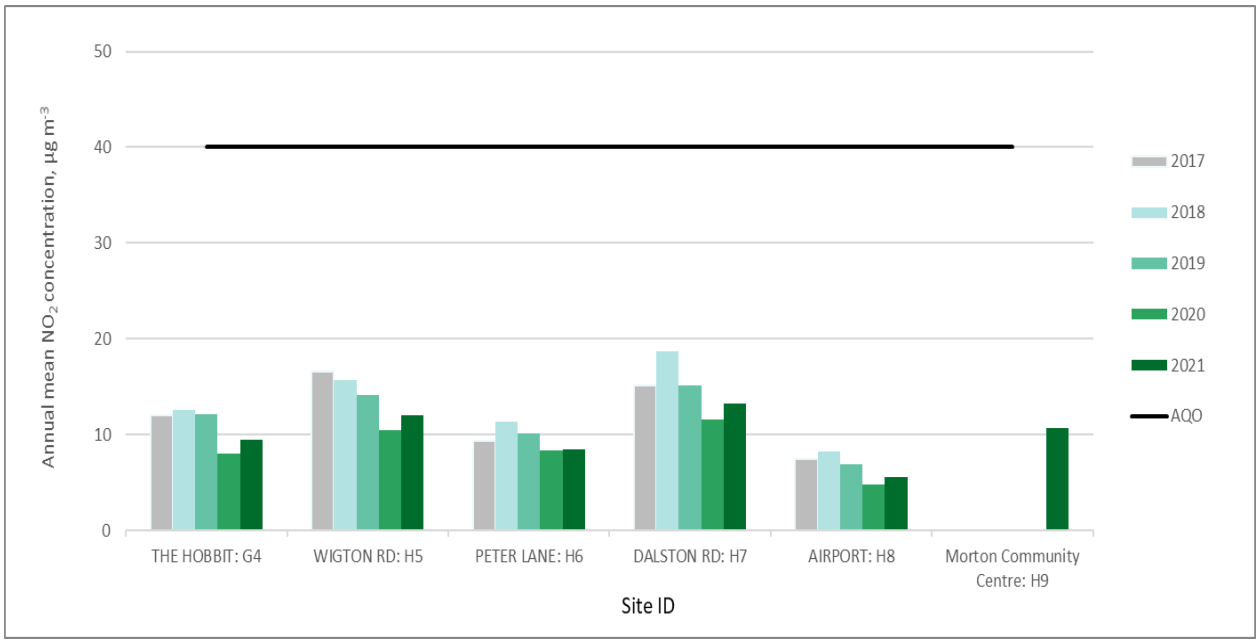


Table A.5 – 1-Hour Mean NO_2 Monitoring Results, Number of 1-Hour Means > 200 µg m^{-3}

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2021 (%) (2)	2017	2018	2019	2020	2021
PM1	339467	555974	Roadside	99.3	46.5	0	0	0	0	0
MCC1	338195	554990	Roadside	78.6	19.8					0

Notes:

Results are presented as the number of 1-hour periods where concentrations greater than 200 µg m^{-3} have been recorded.

Exceedances of the NO_2 1-hour mean objective (200 µg m^{-3} not to be exceeded more than 18 times/year) are shown in **bold**.

If the period of valid data is less than 85%, the 99.8th percentile of 1-hour means is provided in brackets.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Table A.6 – Annual Mean PM_{10} Monitoring Results (µg m^{-3})

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2021 (%) (2)	2017	2018	2019	2020	2021
PM1	339467	555974	Roadside	96.5	45.2	14.6	16.2	18.6	16.4	17.2
MCC1	338195	554990	Roadside	90.3	22.8					11.5

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16.**

Notes:

The annual mean concentrations are presented as µg m^{-3}.

Exceedances of the PM_{10} annual mean objective of 40 µg m^{-3} are shown in **bold**.

All means have been "annualised" as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.6 - Trends in Annual Mean PM_{10} Concentrations

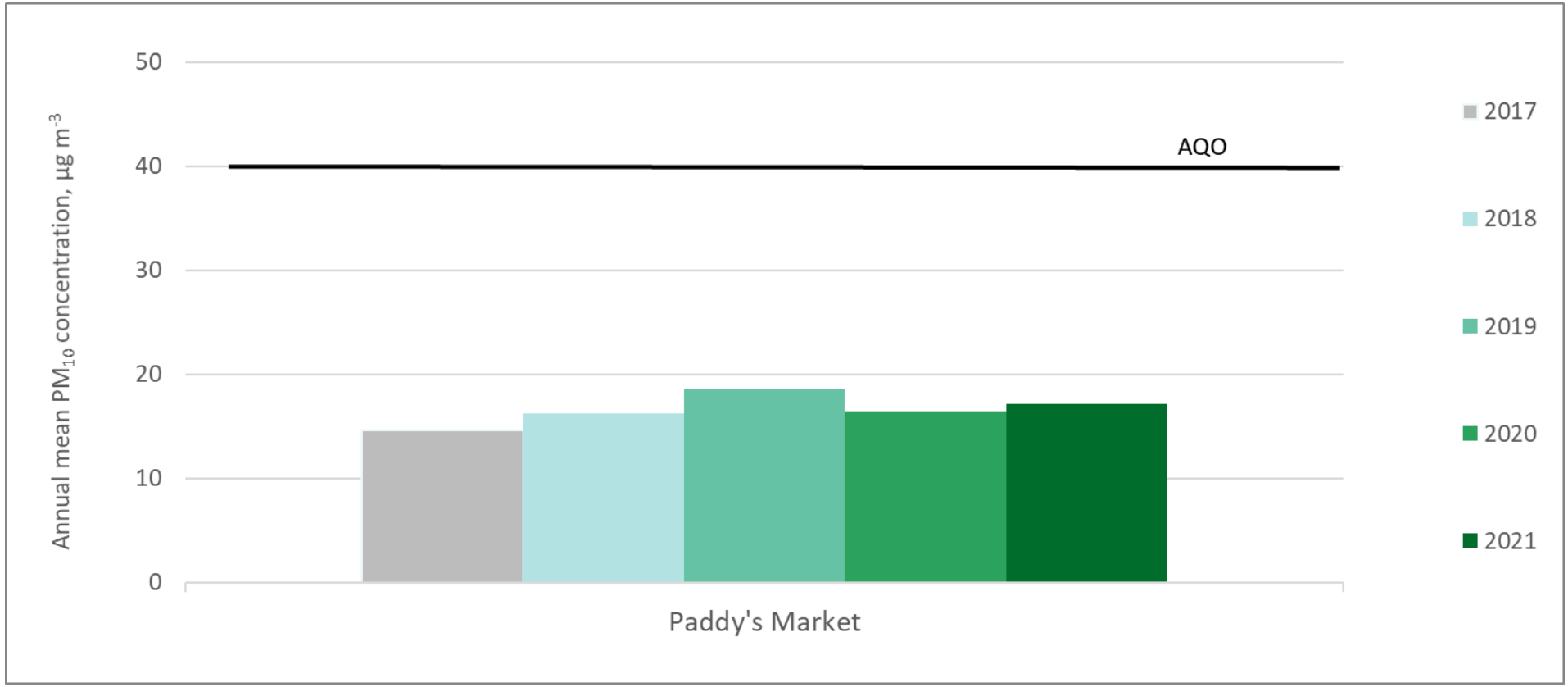


Table A.7 – 24-Hour Mean PM_{10} Monitoring Results, Number of PM_{10} 24-Hour Means > 50 µg m^{-3}

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2021 (%) (2)	2017	2018	2019	2020	2021
PM1	339467	555974	Roadside	96.5	45.2	1	0	5	0	0
MCC1	338195	554990	Roadside	90.3	22.8					0

Notes:

Results are presented as the number of 24-hour periods where daily mean concentrations greater than 50 µg m^{-3} have been recorded.

Exceedances of the PM_{10} 24-hour mean objective (50 µg m^{-3} not to be exceeded more than 35 times/year) are shown in **bold**.

If the period of valid data is less than 85%, the 90.4th percentile of 24-hour means is provided in brackets.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.7 - Trends in Number of 24-Hour Mean PM_{10} Results > 50 µg m^{-3}

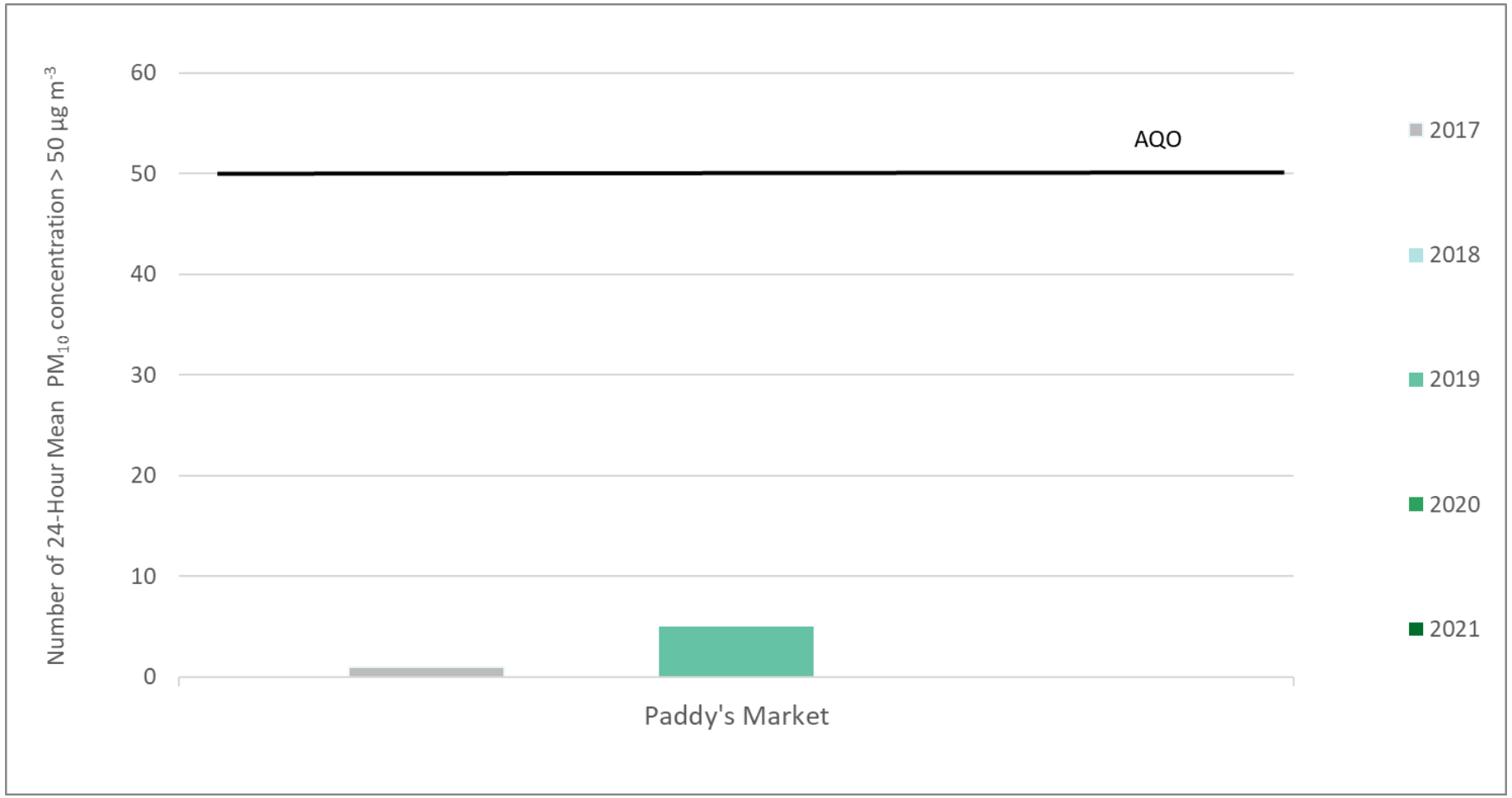


Table A.8 – Annual Mean $PM_{2.5}$ Monitoring Results (µg m^{-3})

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2021 (%) (2)	2017	2018	2019	2020	2021
PM1	339467	555974	Roadside	95.8	44.9	8.58	8.6	10.8	8.4	9.4
MCC1	338195	554990	Roadside	85.8	21.6					8.8

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16**

Notes:

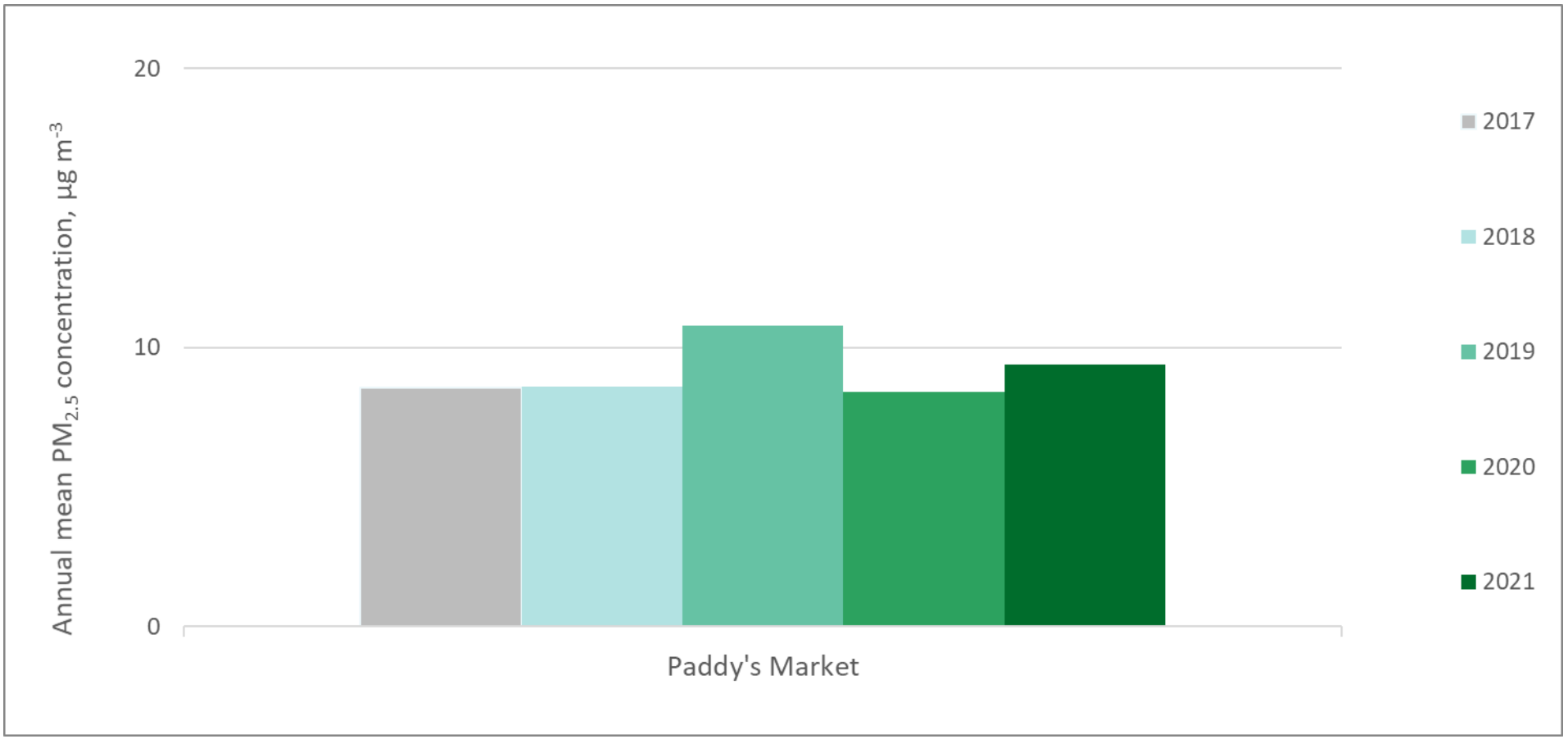
The annual mean concentrations are presented as µg m^{-3}.

All means have been “annualised” as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.8 – Trends in Annual Mean $PM_{2.5}$ Concentrations



Appendix B: Full Monthly Diffusion Tube Results for 2021

Table B.1 – NO_2 2021 Diffusion Tube Results (µg m^{-3})

DT ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean: Raw Data	Annual Mean: Annualised and Bias Adjusted (0.84)	Annual Mean: Distance Corrected to Nearest Exposure	Comment
A1	339995	557188	36.0	31.6	27.4	29.3	27.0		24.7	21.9	30.8	31.2	41.3	33.1	30.4	25.5	-	
A10	340008	556842	45.5	39.3	27.5	34.2	37.3		28.6	35.8	42.8		39.3	34.6	36.3	30.5	-	
A12	339935	557125	30.4	29.7	25.3	30.6	28.8			25.4	29.9	31.9	29.5	28.7	29.0	24.3	-	
A5	339758	558059	32.6	29.0	25.4	29.6	28.4		24.9	24.7	30.3	35.5	38.2	31.3	30.0	25.2	-	
A7	339526	559285	23.0	18.4	17.8	18.4	19.4		15.4		19.5	23.1	24.8	22.8	20.3	17.1	-	
A9	340028	556833	33.4	21.7	26.8	39.7	34.4		31.2	25.7	34.8	35.4	39.5	30.4	32.0	26.9	-	
B4	339434	555638	47.6	40.0	34.9	39.5	38.2		33.5	33.2	41.0	43.3	43.3	37.6	39.2	32.9	-	
B7	340205	555198	39.5	39.3	28.2	36.5	30.2		29.0	28.9	41.5	41.7	44.6	39.7	36.2	30.4	-	
C1	340216	556131	30.2	25.3	19.4	26.7	24.2		21.8	24.0	31.4	31.4	29.9	26.7	26.4	22.1	-	
C2	340069	555955	23.4	19.2	13.0	13.1	13.0		9.5	10.7	15.4	16.1	20.2	19.5	15.8	13.2	-	
C3	340218	555768	28.8	27.3	22.4	31.3	27.7		23.6	24.8	29.7	27.5	29.3	27.2	27.1	22.8	-	
D12	340307	555718	38.5	35.0	22.8	22.8	26.1		23.5	23.6	29.8	34.0	35.9	31.6	29.4	24.7	-	
D7	341593	555893	30.0	27.3	23.1	21.6	30.2		24.3	24.7	34.4	37.3	35.6	34.1	29.5	24.8	-	
E22	339834	556137	33.7	32.1	24.7	25.3	25.8		24.4	24.1	32.9	34.8	36.6	29.8	29.4	24.7	-	
E12	339225	555821	39.1	37.8	27.5	36.5	35.4		32.7	31.9	39.8	38.4	36.5	32.5	35.1	29.5	-	
E15	339091	555736	43.5	30.1	26.0	33.3	28.6		26.9	25.8	33.0	32.2	36.1	32.1	31.4	26.4	-	
E16	339141	555900	42.1	36.2	24.7	37.4	31.9		27.8	29.1	36.8	33.1	33.0	28.7	32.5	27.3	-	
E19	338953	555610	41.0	40.8	24.2	35.9	31.1		29.6	31.9	37.6	39.0	37.0	37.7	35.0	29.4	-	
E6	339467	555974	36.2	30.2	23.0	32.1	27.2								-	-	-	Triplicate Site with E6, E61 and E62 - Annual data provided for E62 only

DT ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean: Raw Data	Annual Mean: Annualised and Bias Adjusted (0.84)	Annual Mean: Distance Corrected to Nearest Exposure	Comment
E61	339467	555974	34.7	29.7	22.9	31.4	26.7								-	-	-	Triplicate Site with E6, E61 and E62 - Annual data provided for E62 only
E62	339467	555974	35.9	27.9	23.2	28.3	25.7								28.7	22.8	-	Triplicate Site with E6, E61 and E62 - Annual data provided for E62 only
E8	339516	556024	49.1	42.5	38.1	49.9	42.8		40.3	40.8	44.8	43.9	47.2	39.4	43.2	36.3	-	
F10	349597	555351	39.1	35.0	32.1	37.3	38.5		32.1	30.7	39.5	34.3	38.6	35.0	35.6	29.9	-	
F7	340708	555240	44.6	38.0	28.8	44.6	40.1		31.5	27.0	39.2	41.0	39.7	32.9	36.9	31.0	-	
F9	341099	554931	42.6	36.1	28.0	41.6	34.3		31.6	31.8	35.3	32.7	37.4	30.8	34.4	28.9	-	
G4	336905	554036	14.8	12.6	9.7	12.2	9.1		8.0	8.5	11.1	11.9	14.2	12.2	11.3	9.5	-	
H5	337643	554100	21.0	16.4	12.7	15.0	10.5		10.7	10.4	12.5	11.7	17.9	18.1	14.2	12.0	-	
H6	337962	553220	16.8	12.5	7.7	13.9	9.6		7.0	9.0	10.3	7.5	8.0	9.4	10.0	8.4	-	
H7	338282	553396	21.0	20.7	13.5	18.2	14.4		11.2	11.8	16.9	15.9	15.1	15.6	15.8	13.2	-	
H8	347874	561254		8.3	5.1	5.3	5.9		6.4	5.8	7.2	6.6	7.2	7.7	6.6	5.5	-	
H9 1	338195	554990								9.5	11.9	12.5	15.2	14.6	-	-	-	Triplicate Site with H9 1, H9 2 and H9 3 - Annual data provided for H9 3 only
H9 2	338195	554990								12.2	12.8	12.0	15.7	15.5	-	-	-	Triplicate Site with H9 1, H9 2 and H9 3 - Annual data provided for H9 3 only
H9 3	338195	554990								10.4	12.0	12.4	16.6	16.1	13.4	10.6	-	Triplicate Site with H9 1, H9 2 and H9 3 - Annual data provided for H9 3 only

☒ **All erroneous data has been removed from the NO_2 diffusion tube dataset presented in Table B.1.**

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16.**

☐ **Local bias adjustment factor used.**

☒ **National bias adjustment factor used.**

☒ **Where applicable, data has been distance corrected for relevant exposure in the final column.**

☒ **Carlisle City Council confirm that all 2021 diffusion tube data has been uploaded to the Diffusion Tube Data Entry System.**

Notes:

Exceedances of the NO_2 annual mean objective of 40 µg m^{-3} are shown in **bold**.

NO_2 annual means exceeding 60 µg m^{-3}, indicating a potential exceedance of the NO_2 1-hour mean objective are shown in **bold and underlined**.

See Appendix C for details on bias adjustment and annualisation.

Appendix C: Supporting Technical Information / Air Quality Monitoring Data QA/QC

New or Changed Sources Identified Within Carlisle City Council During 2021

Carlisle City Council has not identified any new sources relating to air quality within the reporting year of 2022.

Additional Air Quality Works Undertaken by Carlisle City Council During 2021

Carlisle City Council has not completed any additional works within the reporting year of 2021.

QA/QC of Diffusion Tube Monitoring

This section provides detail relating to the following aspects of non-automatic monitoring using diffusion tubes:

Diffusion Tube Supplier

Carlisle City Council diffusion tubes are supplied and analysed by Gradko International using 20% TEA in water.

Gradko participate in the AIR-PT analysis scheme[16]. This is an independent analytical proficiency-testing scheme, operated by LGC Standards and supported by the Health and Safety Laboratory (HSL). Defra and the Devolved Administrations advise that diffusion tubes used for LAQM should be obtained from laboratories that have demonstrated

16 https://laqm.defra.gov.uk/documents/LAQM%20NO2%20Performance%20data_Up%20to%20March%202021_v2.pdf

satisfactory performance in the AIR NO_2 PT scheme. For those reporting periods in 2021 for which Gradko reported results all were re considered satisfactory (based on z-scores less than or equal to 2). The laboratory performance for Gradko is summarised below:

AIR PT Round	AIR PT AR042	AIR PT AR043	AIR PT AR045	AIR PT AR046
Round conducted in the period	January – February 2021	May – June 2021	July – August 2021	September – October 2021
Gradko International	100%	100%	100%	100%

Diffusion Tube Calendar

The diffusion tube calendar used by Carlisle City Council is provided below. This did not deviate significantly from the 2021 Diffusion Tube Monitoring Calendar- except for the last sampling period for which the sampling period was more than 6 six weeks.

Month	Tube On	Tube Off
Jan	06/01/2021	03/02/2021
Feb	03/02/2021	04/03/2021
Mar	04/03/2021	07/04/2021
Apr	07/04/2021	05/05/2021
May	05/05/2021	10/06/2021
Jun	10/06/2021	07/07/2021
Jul	07/07/2021	04/08/2021
Aug	04/08/2021	02/09/2021
Sep	02/09/2021	30/09/2021
Oct	30/09/2021	03/11/2021
Nov	03/11/2021	01/12/2021
Dec	01/12/2021	13/01/2022

Diffusion Tube Annualisation

Annualisation is required when the annual data capture for the diffusion tubes is less than 75 %. There were two sites which required annualisation:

E6 Paddy's Market
H9 Morton Community Centre

The annualisation was carried out using the NO_2 processing tool. Details of annualisation factors and annualised means for these two sites are provided in **Error! Reference source not found.**.

The automatic data for the annualisation was obtained from UK-AIR and included the following background sites:

- Blackpool Marton

- Newcastle Centre
- Preston

Table C.1 – Annualisation Summary for diffusion tubes

Site ID	Annualisation Factor: Blackpool Marton	Annualisation Factor: Newcastle Centre	Annualisation Factor: Preston	Average Annualisation Factor	Raw Data Annual Mean, (µg m^{-3})	Annualised Annual Mean, (µg m^{-3})	With bias factor (0.84) (µg m^{-3})
E6.1	0.9304	0.9773	0.9318	0.9465	28.7	27.1	22.8
E6 2	0.9304	0.9773	0.9318	0.9465	-	-	
E6 3	0.9304	0.9773	0.9318	0.9465	-	-	
H9 1	0.9156	0.9560	0.9605	0.9440	13.4	12.64	10.6
H9 2	0.9156	0.9560	0.9605	0.9440			
H9 3	0.9156	0.9560	0.9605	0.9440			

Diffusion Tube Bias Adjustment Factors

The diffusion tube data presented within the 2022 ASR have been corrected for bias using an adjustment factor. Bias represents the overall tendency of the diffusion tubes to under or over-read relative to the reference chemiluminescence analyser. LAQM.TG16 provides guidance with regard to the application of a bias adjustment factor to correct diffusion tube monitoring. Triplicate co-location studies can be used to determine a local bias factor based on the comparison of diffusion tube results with data taken from NO_x/NO_2 continuous analysers. Alternatively, the national database of diffusion tube co-location surveys provides bias factors for the relevant laboratory and preparation method.

Carlisle City Council have applied a national bias adjustment factor of 0.84 to the 2021 monitoring data. A summary of bias adjustment factors used by Carlisle City Council over the past five years is presented in Table C.2.

Table C.2 – Bias Adjustment Factor

Monitoring Year	Local or National	If National, Version of National Spreadsheet	Adjustment Factor
2021	National	06/22	0.84
2020	National	06/21	0.81
2019	National	03/20	0.93
2018	National	03/19	0.93
2017	National	03/18	0.89
2016	National	03/17	0.94

Local Bias Adjustment

A combined local bias adjustment factor of 0.81 was derived by the collocation of the triplicate tubes and the automatic analysers at Paddy's Market and Morton Community Centre. The bias adjustment was carried out using the NO_2 data processing tool[17] and the summary statistics are provided in Table C.3.

Table C.3 – Local Bias Adjustment Summary

	STEP 3a Local Bias Adjustment Input 1 (Paddy's Market)	STEP 3b Local Bias Adjustment Input 2 (Morton Community Centre)
Periods used to calculate bias	5	2
Bias Factor A	0.81 (0.75 - 0.89)	0.81 (0.52 - 1.76)
Bias Factor B	23% (13% - 34%)	24% (-43% - 91%)
Diffusion Tube Mean (µg m^{-3})	29.0	14.1
Mean CV (Precision)	3.3%	3.4%
Automatic Mean (µg m^{-3})	23.5	11.3
Data Capture	99%	97%
Adjusted Tube Mean (µg m^{-3})	23 (22 - 26)	11 (7 - 25)
Overall Diffusion Tube Precision	Good Overall Precision	Good Overall Precision
Overall Continuous Monitor Data Capture	Poor Overall Data Capture	Poor Overall Data Capture
Local Bias Adjustment Factor	**0.81**	

National Bias Adjustment

The national database of diffusion tube co-location surveys provides bias factors for the relevant laboratory and preparation method. A bias adjustment of 0.84 for the year 2021 (based on 34 studies) has been derived from the national bias adjustment spreadsheet (v06_22). A screenshot of the spreadsheet for Gradko is shown in

Figure C.1.

[17] Diffusion tube data processing tool laqm (defra.gov.uk)

Figure C.1 – National bias adjustment spreadsheet

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 06/22

Follow the steps below **in the correct order** to show the results of **relevant** co-location studies
Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods
Whenever presenting adjusted data, you should state the adjustment factor used and the version of the spreadsheet
This spreadhseet will be updated every few months: the factors may therefore be subject to change. This should not discourage their immediate use.

This spreadsheet will be updated at the end of September 2022
LAQM Helpdesk Website

The LAQM Helpdesk is operated on behalf of Defra and the Devolved Administrations by Bureau Veritas, in conjunction with contract partners AECOM and the National Physical Laboratory.

Spreadsheet maintained by the National Physical Laboratory. Original compiled by Air Quality Consultants Ltd.

Step 1: Select the Laboratory that Analyses Your Tubes from the Drop-Down List

If a laboratory is not shown, we have no data for this laboratory.

Step 2: Select a Preparation Method from the Drop-Down List

If a preparation method is not shown, we have no data for this method at this laboratory.

Step 3: Select a Year from the Drop-Down List

If a year is not shown, we have no data[2]

Step 4:

Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.

If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Local Air Quality Management Helpdesk at LAQMHelpdesk@bureauveritas.com or 0800 0327953

Analysed By[1]	Method	Year[5]	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m³)	Automatic Monitor Mean Conc. (Cm)	Bias (B)	Tube Precision[6]	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in water	2021	R	Gedling Borough Council	12	32	26	23.1%	G	0.81
Gradko	20% TEA in water	2021	UB	West Northamptonshire Council	11	14	10	32.1%	G	0.76
Gradko	20% TEA in water	2021	R	Ards and North Down Borough Council	10	30	22	38.4%	G	0.72
Gradko	20% TEA in water	2021	R	Birmingham City Council	10	33	25	35.2%	G	0.74
Gradko	20% TEA in water	2021	R	Cheshire West and Chester	12	34	29	14.1%	G	0.88
Gradko	20% TEA in water	2021	R	Cheshire West and Chester	12	33	29	12.6%	G	0.89
Gradko	20% TEA in water	2021	R	Lisburn & Castlereagh City Council	12	25	19	31.9%	G	0.76
Gradko	20% TEA in water	2021	R	Nottingham City Council	12	32	35	-8.1%	G	1.09
Gradko	20% TEA in water	2021	R	SOUTHAMPTON CITY COUNCIL	12	34	32	5.2%	G	0.95
Gradko	20% TEA in water	2021	R	SOUTHAMPTON CITY COUNCIL	12	34	27	28.6%	G	0.78
Gradko	20% TEA in water	2021	R	Bath & North East Somerset	12	31	27	15.1%	G	0.87
Gradko	20% TEA in water	2021	R	Bedford Borough Council	11	34	31	7.6%	G	0.93
Gradko	20% TEA in water	2021	R	Bedford Borough Council	11	19	17	11.7%	G	0.90
Gradko	20% TEA in water	2021	R	Blackburn with Darwen Borough Council	12	27	20	32.3%	G	0.76
Gradko	20% TEA in water	2021	R	Brent Council	12	51	46	9.9%	G	0.91
Gradko	20% TEA in water	2021	R	Gateshead Council	10	23	19	23.8%	G	0.81
Gradko	20% TEA in water	2021	R	Gateshead Council	12	25	22	13.7%	G	0.88
Gradko	20% TEA in water	2021	R	Gateshead Council	11	27	25	9.8%	G	0.91
Gradko	20% TEA in water	2021	R	Gateshead Council	12	31	25	26.6%	G	0.79
Gradko	20% TEA in water	2021	R	Gateshead Council	12	32	34	-4.1%	G	1.04
Gradko	20% TEA in water	2021	KS	Marylebone Road Intercomparison	11	53	42	25.0%	G	0.80
Gradko	20% TEA in Water	2021	R	Monmouthshire County Council	11	35	29	21.8%	G	0.82
Gradko	20% TEA in water	2021	R	Belfast City Council	12	25	21	20.9%	G	0.83
Gradko	20% TEA in water	2021	UC	Belfast City Council	11	26	21	25.4%	G	0.80
Gradko	20% TEA in water	2021	R	Belfast City Council	12	42	36	17.7%	G	0.85
Gradko	20% TEA in water	2021	R	Belfast City Council	12	38	27	39.4%	G	0.72
Gradko	20% TEA in water	2021	UB	Dudley MBC	12	20	15	36.0%	G	0.74
Gradko	20% TEA in water	2021	R	Dudley MBC	12	30	29	4.2%	G	0.96
Gradko	20% TEA in water	2021	R	Dudley MBC	12	42	40	5.5%	G	0.95
Gradko	20% TEA in Water	2021	R	Lambeth	10	91	62	46.6%	G	0.68
Gradko	20% TEA in water	2021	R	Lancaster City Council	13	38	32	18.4%	G	0.84
Gradko	20% TEA in water	2021	R	Lancaster City Council	13	28	27	4.9%	G	0.95
Gradko	20% TEA in water	2021	R	Cheltenham Borough Council	12	29	25	13.4%	G	0.88
Gradko	20% TEA in water	2021	R	Preston City Council	12	24	21	12.2%	G	0.89
Gradko	20% TEA in water	2021		**Overall Factor[3] (34 studies)**				Use		0.84

Selection of Appropriate Bias Adjustment Factor

NO_2 diffusion tubes should be corrected for bias. Bias represents the overall tendency of the diffusion tubes to under or over-read relative to the reference chemiluminescence analyser.

For the purpose of adjusting the 2021 diffusion tubes results, both the combined local (0.81) and the national bias adjustment factor (0.84), were compared. Given, the poor overall data capture for the automatic analysers at both Paddy's Market and Morton Community Centre, the national factor was chosen. Using the national factor is consistent with previous ASRs.

NO_2 Fall-off with Distance from the Road

Wherever possible, monitoring locations are representative of exposure. However, where this is not possible, the NO_2 concentration at the nearest location relevant for exposure has been estimated using the Diffusion Tube Data Processing Tool/NO_2 fall-off with distance calculator available on the LAQM Support website. Where appropriate, non-automatic annual mean NO_2 concentrations corrected for distance are presented in Table B.1.

No diffusion tube NO_2 monitoring locations within Carlisle City Council required distance correction during 2021.

QA/QC of Automatic Monitoring

Ricardo provides data management and local site operator (LSO) duties for the automatic monitoring sites within Carlisle City Council. The instrumentation is calibrated every two weeks and a full site service is carried out every six months. The calibration certificates are provided in in the following six pages. The QA/QC is accredited to ISO 17025. All data are ratified to all LAQM reporting requirements. Measurement data are available through UKAIR.

PM_{10} and $PM_{2.5}$ Monitoring Adjustment

PM_{10} and $PM_{2.5}$ are measured using BAM 1020 heated instrument. For the PM_{10} instrument a slope correction factor of 0.9662 is applied. No slope correction is required for the $PM_{2.5}$.

Automatic Monitoring Annualisation

Due to the relocation of the automatic monitoring station from Paddy's Market to Morton Community Centre in 2021 all automatic monitoring required annualisation. The method for annualisation automatic is described in Box 7.9 of TG16. For Paddy's Market, the

period means were calculated for the period 1st January to 2021 to 21st June 2021 and for Morton Community Centre for the period 1st October 2021 to 31st December 2021. However, as the data capture for the automatic analysers at Morton Community Centre was less 25 %, annualisation was only carried out for Paddy's Market. The background monitoring stations used in the annualisation, the annual and period means, the Am/Pm ratio and the resultant annualised concentrations are shown in Table C.4**Error! Reference source not found.**.

Table C.4 – Annualisation summary for automatic monitoring

Pollutant	Mean as measured, µg m^{-3}	Background site	Annual mean, µg m^{-3}	Period mean, µg m^{-3}	Ratio, Am/Pm	Annualised average mean, µg m^{-3}
NO_2	23.1	Blackpool Marton	10.1	10.4	0.964	22.5
		Newcastle Centre	28.3	28.1	1.007	
		Preston	20.1	21.2	0.949	
					0.973	
PM_{10}	17.9	Blackpool Marton	12.2	13.1	0.936	17.2
		Newcastle Centre	14.3	14.0	1.019	
		Preston	12.5	13.7	0.913	
					0.956	
$PM_{2.5}$	9.9	Blackpool Marton	7.3	8.1	0.910	9.4
		Newcastle Centre	7.1	6.9	1.028	
		Preston	7.5	8.3	0.905	
					0.948	

NO_2 Fall-off with Distance from the Road

Wherever possible, monitoring locations are representative of exposure. However, where this is not possible, the NO_2 concentration at the nearest location relevant for exposure has been estimated using the NO_2 fall-off with distance calculator available on the LAQM Support website. Where appropriate, non-automatic annual mean NO_2 concentrations corrected for distance are presented in Table B.1.

No automatic NO_2 monitoring locations within Carlisle City Council required distance correction during 2021.

Appendix D: Map(s) of Monitoring Locations and AQMAs

Figure D.1 – Location of diffusion tubes within Carlisle City Council area

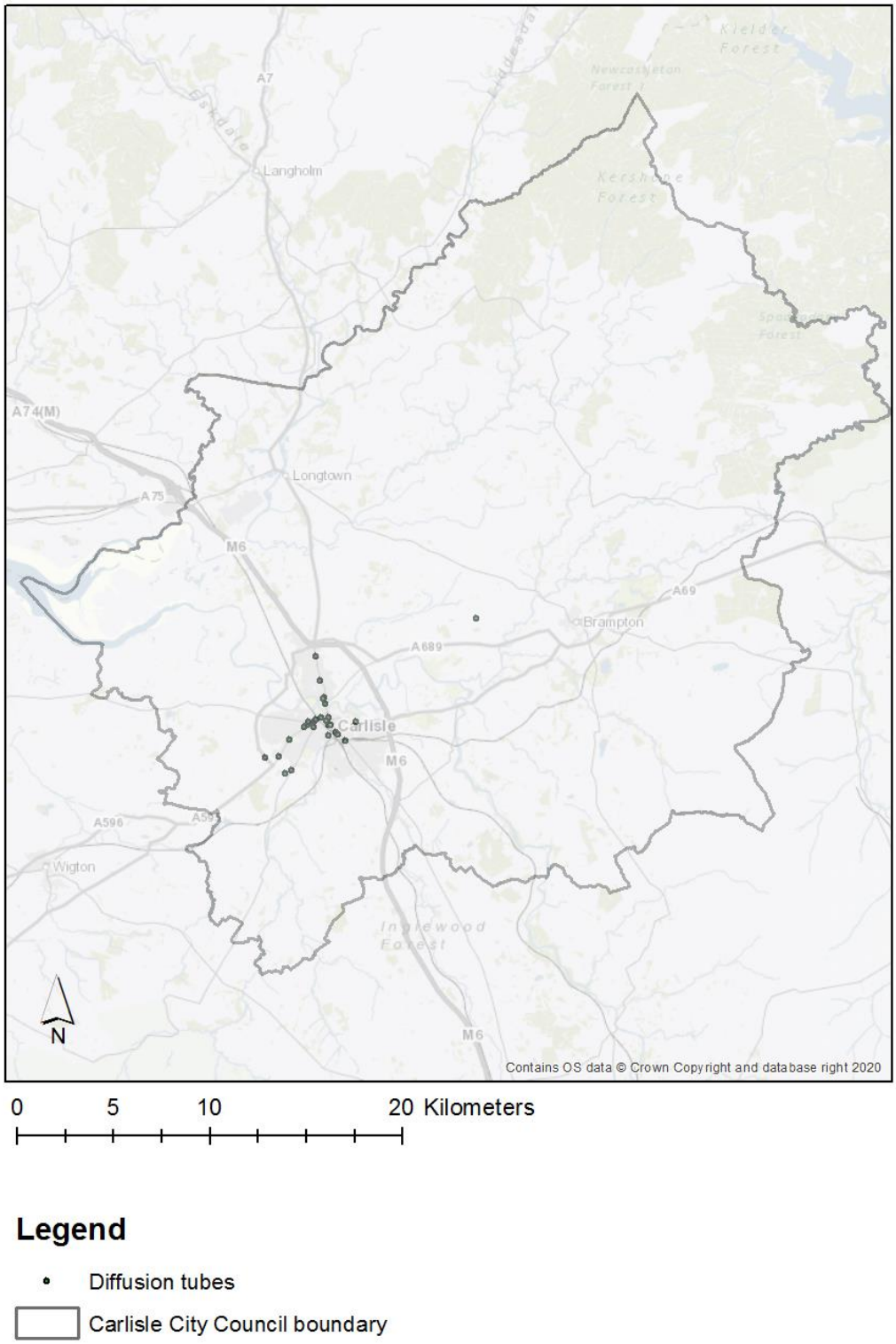


Figure D.2 – Location of diffusion tubes within Carlisle City Council area (with Site IDs)

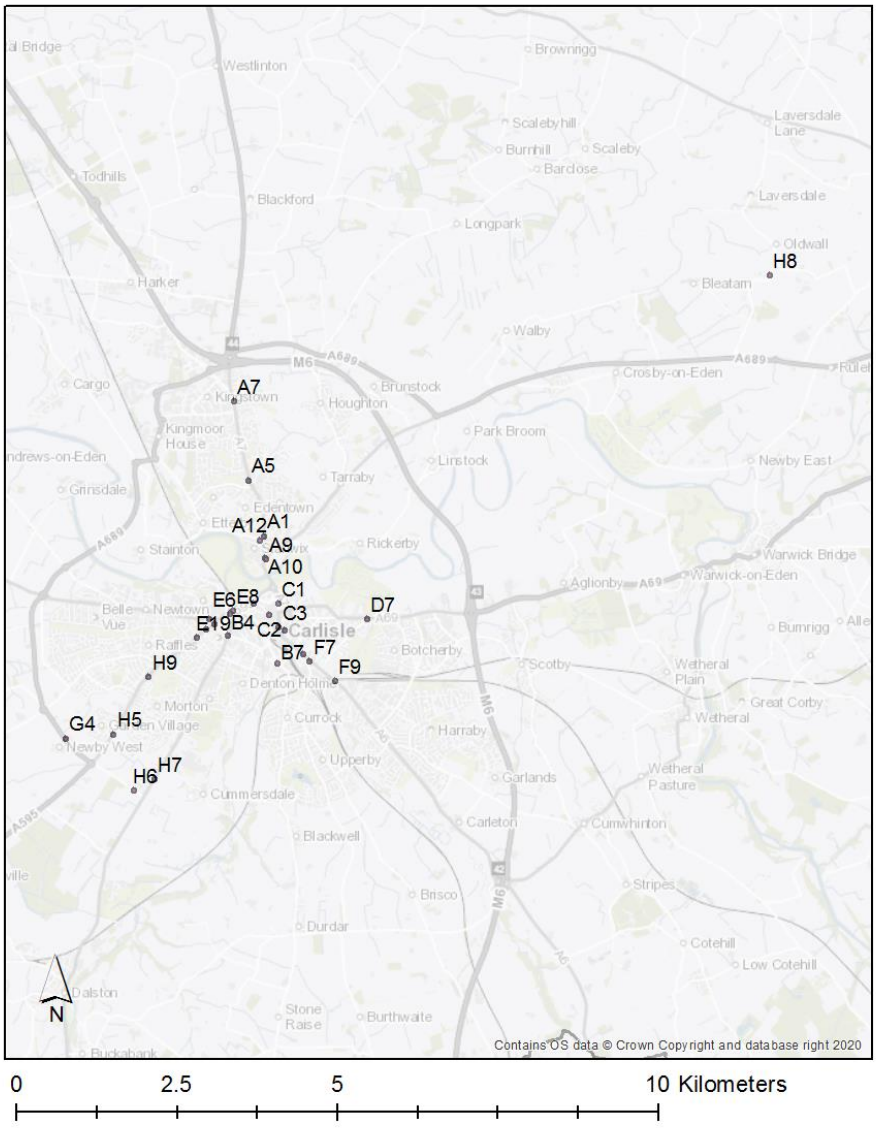


Figure D.3 – Location of air quality management areas and diffusion tubes (within city)

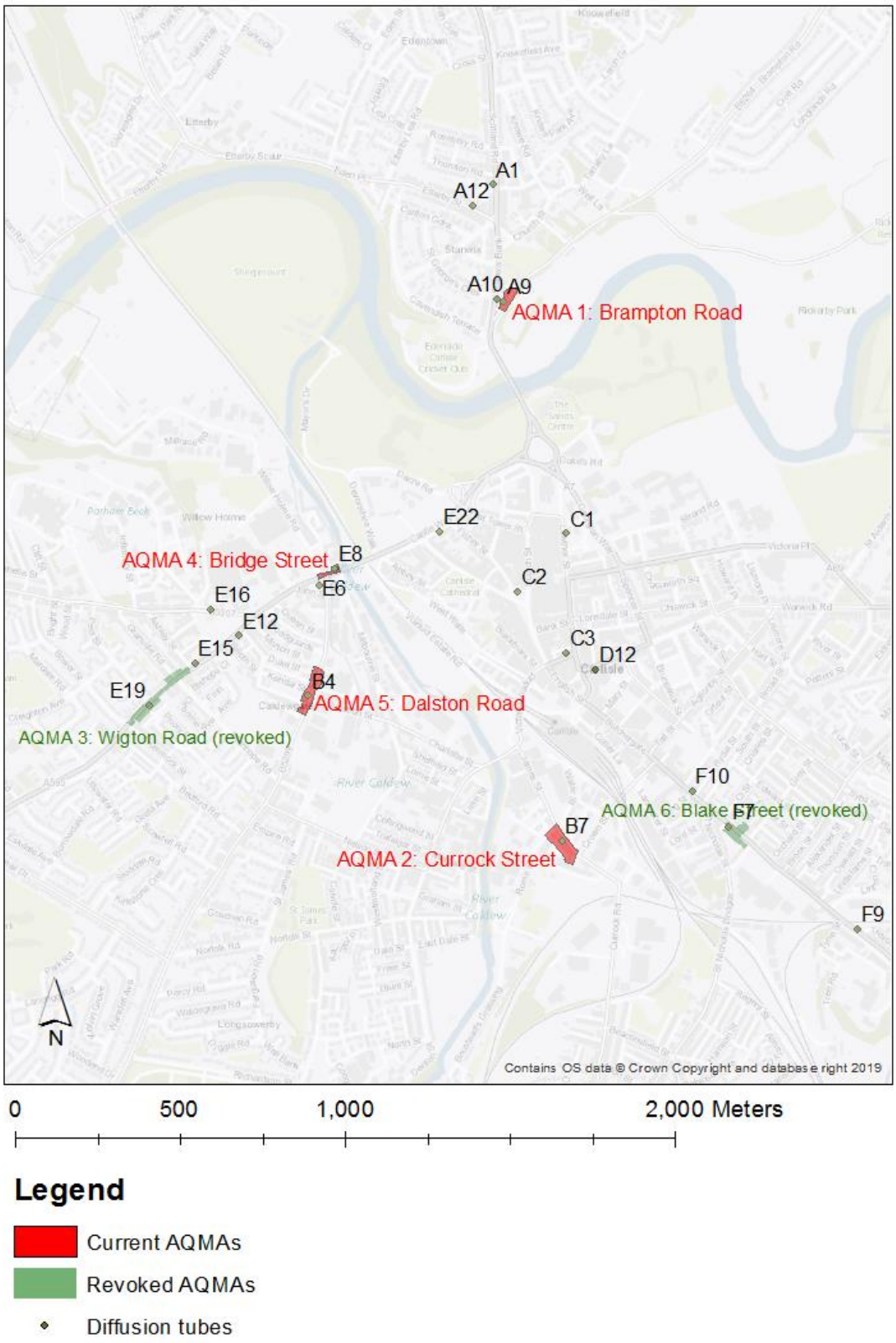
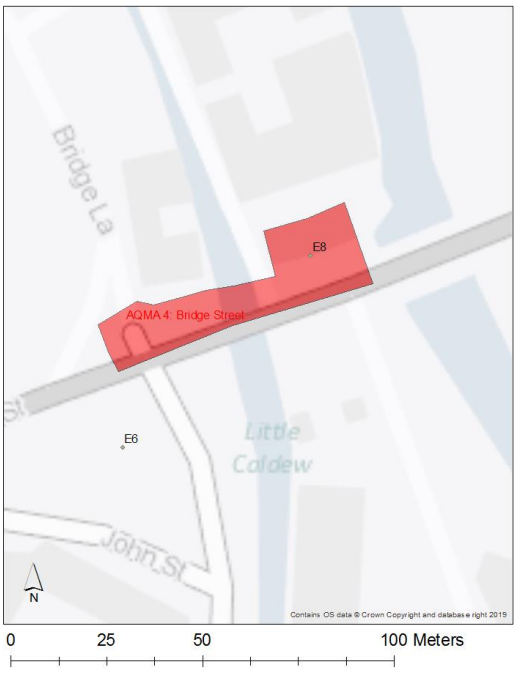


Figure D.4 – Location of air quality management areas (zoomed in)

AQMA 1: Brampton Road

AQMA 2: Currock Street

AQMA 4: Bridge Street



AQMA 5: Dalston Road

Figure D.5 – Location of diffusion tubes in outlying areas

Appendix E: Summary of Air Quality Objectives in England

Table E.1 – Air Quality Objectives in England[18]

Pollutant	Air Quality Objective: Concentration	Air Quality Objective: Measured as
Nitrogen Dioxide (NO_2)	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean
Nitrogen Dioxide (NO_2)	40 µg m^{-3}	Annual mean
Particulate Matter (PM_{10})	50 µg m^{-3}, not to be exceeded more than 35 times a year	24-hour mean
Particulate Matter (PM_{10})	40 µg m^{-3}	Annual mean
Sulphur Dioxide (SO_2)	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean
Sulphur Dioxide (SO_2)	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean
Sulphur Dioxide (SO_2)	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean

[18] The units are in microgrammes of pollutant per cubic metre of air (µg m^{-3}).

Glossary of Terms

Abbreviation	Description
AQAP	Air Quality Action Plan - A detailed description of measures, outcomes, achievement dates and implementation methods, showing how the local authority intends to achieve air quality limit values'
AQMA	Air Quality Management Area – An area where air pollutant concentrations exceed / are likely to exceed the relevant air quality objectives. AQMAs are declared for specific pollutants and objectives
ASR	Annual Status Report
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges – Air quality screening tool produced by National Highways
EU	European Union
FDMS	Filter Dynamics Measurement System
LAQM	Local Air Quality Management
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
PM_{10}	Airborne particulate matter with an aerodynamic diameter of 10µm or less
$PM_{2.5}$	Airborne particulate matter with an aerodynamic diameter of 2.5µm or less
QA/QC	Quality Assurance and Quality Control
SO_2	Sulphur Dioxide

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